THE JOURNAL
Volume 18, No. 8
pp. 225-258

CERAMIC ABSTRACTS
Volume 14, No. 8
pp. 177-204

# AMERICAN CERAMIC SOCIETY

AUGUST • 1935

MONTHLY PUBLICATIONS DEVOTED TO THE ARTS AND SCIENCES RELATED TO THE SILICATE INDUSTRIES

# Table of Contents

Vol. 18 AUGUST, 1935 No. 8

## The Journal of the American Ceramic Society

Use of a Nickel Dip in Enameling Practice ..... 225
By J. E. Hansen and J. T. Irwin

Mechanics of Enamel Suspension, II. Electrodialysis of Some Enamels and Glasses ..... 230
By R. M. King

Observations of the Action of Steam on Glass ..... 233
By O. G. Burch

Effect of Temperature Treatment on Glass-to-Metal Seals ..... 239
By J. T. Littleton

Mortars Suitable from the Standpoint of Water-Tightness in Unit Masonry ..... 245
By L. A. Palmer

Influence of Sodium Carbonate in a Fireclay Sewer-Pipe Body ..... 251
By W. L. Carter, G. H. Duncombe, E. E. Hillyer, and R. M. King

Vol. 14 No. 8

## Ceramic Abstracts

Abrasives ..... 177
Art and Archeology ..... 178
Cements ..... 181
Enamel ..... 182
Glass ..... 184
Structural Clay Products ..... 188
Refractories ..... 189
Terra Cotta ..... 192
Whiteware ..... 193
Equipment and Apparatus ..... 194
Kilns, Furnaces, Fuels, and Combustion ..... 196
Geology ..... 199
Chemistry and Physics ..... 200
General ..... 202

# The American Ceramic Society Trustees and Officers for 1935–1936

**President:** J. M. McKinley, North American Refractories Co., Cleveland, Ohio
**Vice-President:** Francis C. Flint, Hazel-Atlas Glass Co., Washington, Pa.
**Treasurer:** H. B. Henderson, H. B. Henderson Co., New Brighton, Pa.
**Secretary-Editor:** Ross C. Purdy, 2525 North High St., Columbus, Ohio
**Past-President:** W. Keith McAfee, Universal Sanitary Mfg. Co., New Castle, Pa.
**Past-President:** John C. Hostetter, Corning Glass Works, Corning, N. Y.

## Trustees from the Industrial Divisions

**Art:** Frederick H. Rhead, Homer Laughlin China Co., East Liverpool, Ohio
**Enamel:** W. C. Lindemann, Lindemann & Hoverson Co., Milwaukee, Wis.
**Glass:** J. T. Littleton, Corning Glass Works, Corning, N. Y.
**Materials and Equipment:** Victor V. Kelsey, Consolidated Feldspar Corp., Trenton, N. J.
**Refractories:** R. B. Sosman, United States Steel Corp., Kearny, N. J.
**Structural Clay Products:** R. B. Keplinger, Metropolitan Paving Brick Co., Canton, Ohio
**Terra Cotta:** R. L. Clare, Federal Seaboard Terra Cotta Corp., Woodbridge, N. J.
**White Wares:** Perry D. Helser, General Ceramics Co., New York, N. Y.

## Industrial Divisions

**Art**
*Chairman:* L. E. Barringer, General Electric Co., Schenectady, N. Y.
*Secretary:* C. M. Harder, N. Y. State College of Ceramics, Alfred, N. Y.

**Enamel**
*Chairman:* R. M. King, Ohio State University, Columbus, Ohio
*Secretary:* B. J. Sweo, National Bureau of Standards, Washington, D. C.

**Glass**
*Chairman:* U. E. Bowes, Owens-Illinois Glass Co., Alton, Illinois
*Secretary:* S. R. Scholes, N. Y. State College of Ceramics, Alfred, N. Y.

**Materials and Equipment**
*Chairman:* C. H. Peddrick, Jr., United Feldspar Corp., 10 E. 40th St., New York, N. Y.
*Secretary:* J. E. Eagle, Vitro Mfg. Co., Pittsburgh, Pa.

**Refractories**
*Chairman:* R. B. Sosman, United States Steel Corp., Kearny, N. J.
*Secretary:* H. M. Kraner, Corhart Refractories Co., Louisville, Ky.

**Structural Clay Products**
*Chairman:* A. F. Greaves-Walker, Univ. of North Carolina, Raleigh, N. C.
*Secretary:* G. H. Duncombe, 150 East Frambes Ave., Columbus, Ohio

**Terra Cotta**
*Chairman:* J. L. Carruthers, Ohio State University, Columbus, Ohio.
*Secretary:* H. E. Davis, Federal Seaboard Terra Cotta Corp., Woodbridge, N. J.

**White Wares**
*Chairman:* T. A. Klinefelter, National Bureau of Standards, Washington, D. C.
*Secretary:* S. J. McDowell, General Ceramics Co., Keasbey, N. J.

## Local Sections

**Baltimore-Washington**
*Chairman:* Roy A. Blunt, Buck Glass Co., Baltimore, Md.
*Secretary:* G. H. Spencer-Strong, Porcelain Enamel & Mfg. Co., Baltimore, Md.

**California**
*Chairman:* F. A. McCann, Pacific Clay Products Co., Los Angeles, Calif.
*Secretary:* T. S. Curtis, Industrial Research Laboratories, Huntington Park, Calif.

**Central Ohio**
*Chairman:* W. C. Rueckel, Ohio State Univ. Engineering Experiment Station, Columbus, Ohio
*Secretary:* C. A. Austin, Battelle Memorial Institute, Columbus, Ohio

**Chicago**
*President:* G. G. Hanson, Consolidated Feldspar Corp., Chicago, Ill.
*Secretary:* H. V. Kaeppel, Industrial Publications, Inc., 59 E. Van Buren St., Chicago, Ill.

**Michigan-Northwestern Ohio**
*Chairman:* P. W. Dager, Champion Spark Plug Co., Detroit, Mich.
*Secretary:* Macon C. Trabue, Mt. Clemens Pottery Co., Mt. Clemens, Mich.

**Pacific-Northwest**
*President:* H. R. Kreitzer, Columbia Brick Co., Portland, Ore.
*Secretary:* Hewitt Wilson, Univ. of Washington, Seattle, Wash.

**Pittsburgh**
*Chairman:* R. E. Birch, Harbison-Walker Refractories Co., Pittsburgh, Pa.
*Secretary:* Earl C. Petrie, Mellon Institute, Pittsburgh, Pa.

**St. Louis**
*Chairman:* J. W. Wright, Owens-Illinois Glass Co., Alton, Ill.
*Secretary:* Burnett Purcell, Northwestern Terra Cotta Co., St. Louis, Mo.

**Committee on Publications**
*Chairman:* Louis Navias, General Electric Co., Schenectady, N. Y.
M. F. Beecher, Norton Co., Worcester, Mass.
L. J. Trostel, General Refractories Co., Baltimore, Md.
R. M. King, Ohio State University, Columbus, Ohio

**Editorial and Advertising Offices:**
The American Ceramic Society, 2525 North High St., Columbus, Ohio

*Publication Office:* 20th and Northampton Sts., Easton, Pa.

**Entered as second-class matter at the post office at Easton, Pa., under the Act of March 3, 1879.**
***(Copyright 1935, American Ceramic Society, Inc.)***
**Subscription fifteen dollars ($15.00) a year. Single numbers $1.50**
***(Foreign and Canadian postage, 50c additional on subscriptions)***

# THE USE OF A NICKEL DIP IN ENAMELING PRACTICE*

By J. E. Hansen and J. T. Irwin

Abstract

The compositions of various nickel salt solutions now being used commercially in enameling practice and reasons for their use are given. The advantages to be gained are better adherence of enamel to the metal, decreased fishscaling, and control of copperheading conditions. Methods for control of $p_H$ and for analysis of solutions are given.

## I. Introduction

The use of a so-called "nickel dip" or a solution of nickel salts in the preparatory treatment of sheet iron or steel ware for porcelain enameling has long been known, although little reference to any published work on the subject has been available until recently.[1]

## II. Adherence Elements

Cobalt oxide is favorably known as an adherence-promoting ingredient of enamels. Nickel oxide likewise promotes adherence, although to a lesser degree. Since, however, the presence of either or both of these oxides in frit in an amount large enough to promote such adherence renders the enamel coating dark in color, many enamelers, hopeful of developing light-colored ground-coat or light-colored single-coat enamels, have turned to other methods of promoting adherence and of minimizing the defects of fishscaling, copperheading, and chipping, inherent to such practice.

Reasoning that a layer of the adherence-promoting elements at the interface of the enamel and the metal should promote adherence qualities without coloring the entire thickness of the layer, attempts were made to use deposits of cobalt and (or) nickel metal, oxides, or salts as an applied treatment on the steel before application of the enamel. Demonstrated success has been attained by several of such methods, but only the methods involving solutions of nickel salts are presented here.

## III. Plating on Iron

An elementary experiment to demonstrate galvanic plating is that of dipping a clean iron nail or wire in a solution of blue vitriol or copper sulfate, whereupon the metallic copper plates on the iron, the latter going into solution in an amount chemically equivalent to the copper plating out. Such galvanic plating is possible because of the following relative positions of iron and copper in the electromotive series of the metals: manganese + 1.075, zinc + 0.770, cadmium + 0.420, *iron* + 0.340, *cobalt* + 0.232, *nickel* + 0.228, tin + 0.192, lead + 0.148, hydrogen 0.000, and *copper* − 0.336.

Like copper, cobalt and nickel are below iron in the electromotive series and hence can be galvanically plated on iron, if proper conditions exist in the solution.

The amount of deposit on the steel or iron is dependent upon the surface characteristics of the iron itself, the concentration of nickel ions, relative comparative acidity of the nickel solution, presence of buffer salts, temperature of the solution, and length of time of treatment.

### (1) Preparation of Iron

Proper surface characteristics of the iron involve thorough removal of oil, grease, and drawing compound and pickling to remove scale and other forms of iron oxide.

### (2) Nickel Salt

Either single nickel salts ($NiSO_4 \cdot 7H_2O$) or double nickel salts ($NiSO_4 \cdot (NH_4)_2SO_4 \cdot 6H_2O$) may be used as a source of nickel. The former contains 20.9% metallic nickel and the latter, only 14.85% metallic nickel; per unit of nickel, the former is ordinarily the more economical for use.

In some enameling plants where nickel dips are used, no attempt is made to measure or control the relative acidity ($p_H$) of the solution, but experimental work has demonstrated that the best deposit is obtained when the solution is held at a $p_H$

* Presented at the Annual Meeting, American Ceramic Society, Buffalo, N. Y., February, 1935 (Enamel Division).

[1] (*a*) G. W. Hofstetter, "Suggestions on Nickel Pickling," *Better Enameling*, **2** [12] 9 (1932); "Nickel Bath in the Pickle Room," *Enamelist*, **12** [1] 15–16 (1934).
(*b*) F. R. Porter, "Physics and Chemistry of Nickel Pickling," *Better Enameling*, **4** [1] 18–19 (1933).
(*c*) W. C. Lindemann, "Pickle Room Control for Porcelain Enameling Plants," *Jour. Amer. Ceram. Soc.*, **14** [9] 631–33 (1931).

between 5.6 and 6.2. Operators, who recognize this, usually work between such limits.

### (3) Buffer Salt

Boric acid, with or without ammonium carbonate and (or) ammonium hydroxide, is the usual buffer salt employed. When acidity rises (lowered $p_H$), due to carry-over of acid from the pickling tank, ammonium carbonate or hydroxide is added to restore the solution to the proper $p_H$.

### (4) Temperature

Temperature of operation and length of time of treatment in the solution depends upon local conditions and the particular object of using the process.

## IV. Operating Conditions

Operating conditions in several representative plants are shown in Table I.

### (1) Strength of Nickel Solution

As will be noted, the 8-ounce per gallon solution of single nickel salts is used with a white ground coat, whereas the reported users of cobalt ground coats employ solutions of 4- to 5-ounces per gallon strength or weaker. Solutions too high in nickel-salt content are reported to cause difficulties in dipping and draining enamels, as they highly "set-up" the enamel on the ware and cause streaked enamel as well as occasional blistering.

Ware heavily "nickeled," if scratched before coating with enamel, oftentimes shows a row of blisters over the scratch after firing.

## V. Adherence Test of Nickeled Iron

Nickel dips, properly used, unquestionably are efficacious in promoting the formation of bond and adherence between ferrous sheet-metal and white ground coats or the single-coat colored enamels applied directly on the metal for some types of cheaper enameled ware. This is demonstrated in Figs. 1 and 2, showing results of impact tests on two pieces of enameled metal, the former being normally pickled ware and the latter normally pickled but nickel-dipped in addition, each having the same enamel coating and firing treatment. The "un-nickled" sample shows the enamel chipped off, leaving the bright steel exposed, whereas the "nickled" sample, although chipped, shows a large portion of the enamel adhering and no bright steel exposed.

TABLE I

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| | 8 oz./gal. | 4 oz.–5 oz./gal. | 4.25 oz./gal. | 0.4 oz./gal. | 2 oz./gal. |
| Composition | S.N.* 0.25 oz./gal. $H_3BO_3$ | S.N. 0.25 oz./gal. $H_3BO_3$ | D.N.** 0.25 oz./gal. $H_3BO_3$ | S.N. 0.053 oz./gal. $H_3BO_3$ 0.053 oz./gal. $(NH_4)_2CO$ | S.N. 0.25 oz./gal. $H_3BO_3$ |
| Relative acidity ($p_H$) | 5.6–6.4 | 5.6–6.2 | 5.2–6.5 | No control | 5.6–6.4 |
| Time in solution (min.) | 15 | 5 | 3–5 | 20 | 10 |
| Temp. of solution (°F) | 170–180 | 110–120 | 180–190 | 180–190 | 160–170 |
| Used with | White ground coat | Cobalt ground coat to increase adherence and eliminate copperheads | Cobalt ground coat to prevent fishscale and increase adherence | Cobalt ground coat to lessen fishscale hazard with low temperature firing | Cobalt ground coat to increase adherence and eliminate copperheads |
| Control of nickel | Titration | Titration | Block comparator | Precipitate iron and compare with standard | Titration |

* Single nickel salts.
** Double nickel salts.

No. 4 adds 0.25 oz./gal. single nickel salts, 0.03 oz./gal. each of boric acid and ammonium carbonate each morning; also adds 0.07 oz./gal. single nickel salts and 0.009 oz./gal. each of boric acid and ammonium carbonate with each basket of ware.

## VI. Nickeling Minimizes Fishscaling

In the past, most enamelers have thought nickel dips to be unnecessary in conjunction with cobalt-bearing ground coats and the usual processing methods on recognized grades of enameling iron or steel. With the definite trend, however, toward firing ground coats at lower temperatures, nickel

dips can be recommended to assist in the promotion of adherence of the enamel to the metal and to minimize fishscaling.

## VII. Nickeling Lessens Copperheading

It has also been demonstrated in practice that a nickel dip minimizes copperheading of cobalt ground coats. In some instances, this copperheading may have been due to characteristics of the enameling metal used, to furnace firing conditions, to the type of ware, or to other local conditions, but eliminating the cause of copperheads from any discussion here, the fact remains that a nickel dip often is a remedy for the condition. It is suggested that the nickel coating may prevent abnormal surface oxidation of the metal and in this manner may operate to prevent copperheading.

FIG. 1.—Normally pickled ware (not "nickeled") coated with one coat on steel green colored enamel; note poor adherence of point of impact test and fishscaling.

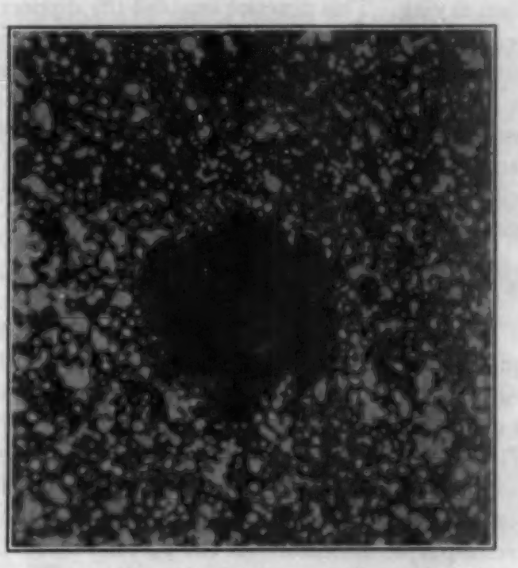


FIG. 2.—Normally pickled steel, given nickel-dip treatment and coated with same enamel as in Fig. 1; note excellent adherence at point of impact test and freedom from fishscaling. This sample was stippled with white enamel.

## VIII. Operation of Nickel Dipping

Operation of a nickel-dipping tank usually necessitates the addition of but one tank of solution to the usual pickling procedure and installation. Regular practice is followed, involving grease removal from the ware by annealing or by alkaline cleaner solutions, rinsing, acid-pickling, and a thorough rinsing, preferably in warm and running water. The ware should then go into the nickel solution.

### (1) Strength of Solution

This solution should preferably be made up from single nickel salts and of 8-ounce per gallon strength for white ground coats, but of only 4- or 2-ounce per gallon strength for cobalt ground coats or most single-coat colored enamels. Definite recommendations will depend upon local conditions and the particular object to be gained in using the solution. Approximately $^1/_4$ ounce of boric acid per gallon of solution should be added as a buffer salt and to bring the solution within the preferred $p_H$ range.

### (2) The Tank

The tank used for the nickel solution should be of wood or should be lead-lined, since the solution obviously will react with an iron tank. Similarly, an iron steam coil for heating is contra-indicated, and lead should be used.

### (3) Temperature and Length of Treatment

The operating temperature should preferably be in the range of 160 to 180°F. The length of time of treatment must be governed by the time necessary to produce the desired results. It may be

pointed out that too long a time of treatment in some cases defeats the object in view, apparently by preventing bonding action from the heavy deposit of nickel.

**(4) Rinsing**

Following the nickel treatment, the ware is ordinarily neutralized in the conventional manner, then dried, and processed. One user, however, has recently achieved better results when dipping enamels on "nickeled" ware by rinsing the ware thoroughly in water only after the nickel treatment (not neutralizing in an alkaline bath) and then drying. This practice enabled the dippers to produce more evenly applied coatings. The practice is apparently justified because the nickel bath is only slightly acidic, but this deviation from usual methods has not as yet been proved satisfactory in commercial production. This trouble will probably not be noticed if the ware is sprayed with enamel instead of being dipped.

**(5) Control of Solution**

During use, the solution should be checked frequently for nickel content and relative acidity (the $p_H$). Nickel content may be determined by using a nickel block comparator or by analytical methods. The $p_H$ may be checked by filtering the solution and using a LaMotte hydrogen-ion comparator block of the 5.2 to 6.8 range, employing bromcresol-purple indicator. If the $p_H$ falls below 5.6, as will be the case when too much acid carries over from the pickling tank, either ammonium carbonate or ammonia water should be added to bring the $p_H$ to 5.6 or higher. If the solution should become too alkaline, sulfuric acid should be added until the $p_H$ drops to 6.4 or lower.

The proper concentration of nickel salts should be maintained in the tank by such daily treatment or other regular additions as may be necessary. All sampling of the solution for tests should be done with the solution at the proper liquid level. When water is added to replace evaporation losses, the solution should be thoroughly stirred or agitated to insure uniform composition.

**(6) Removal of Sludge**

As the solution grows older, more and more iron hydroxide separates out in the tank as a brown sludge. Some of this, with perhaps some nickel carbonate, rises to the surface of the bath and should be skimmed off periodically. In some instances, a continuous filtering system, similar to that often used on nickel plating tanks, has been recommended. This system involves a pump and a filter press through which the solution is circulated. The filter-press, however, may not be built of iron, with which the nickel solution would react, but should be made of wood, lead, or other metal.

If no continuous filtering mechanism is used, when the sludge reaches such a point that it forms a scum on the ware as it leaves the nickel tank, one of two procedures can be followed. The sludge and the solution may be washed out of the tank and discarded or ammonia may be added until the $p_H$ is 6.4; the tank is heated to 180°F with air agitation to oxidize the iron and then allowed to cool without any agitation. After standing over night, the sludge will settle to the bottom and the nickel solution can be siphoned off, preferably through a filter, into another tank. The sludge can then be cleaned from the tank, the tank washed thoroughly, and the nickel solution siphoned back into it. Water, nickel salts, and boric acid, in proper proportions, are then added until the tank is restored to its normal volume and concentration. Acid is added, if necessary, to bring the $p_H$ value within the specified limits.

There is also a formation of a thin coat of iron hydroxide on the surface of the ware, which is not removed by rinsing or by neutralizing. This hydroxide coating is in evidence even with a freshly made nickel solution, but it is being eliminated by one user by giving the nickel-treated ware a rinse in a tank of $^1/_{10}\%$ sulfuric acid following the nickel dip and then neutralizing as usual. This concentration of sulfuric acid is sufficient to dissolve the hydroxide formed on the surface, but it is not of sufficient strength to remove any of the nickel deposit.

**(7) Repickling**

One of the biggest objections to the use of a nickel dip is the difficulty of repickling the ware if, under shop operating conditions, this is necessary. Such repickled ware often causes blistering in the enamels applied thereon. One user has satisfactorily solved this condition by segregating this ware, recleaning as usual in an alkaline cleaner, and rinsing; then repickling for only three minutes and giving a second light nickel dip.

## IX. Analytical Solutions and Methods

The solutions required for the determination of the nickel content of a nickel bath are as follows:

(1) Standard nickel-salt solution: dissolve 2 ounces single nickel salts in 1 quart of distilled water.
(2) Standard potassium cyanide solution: dissolve 75 grams 95 to 96% KCN in distilled water and make up to 1 liter.
(3) Standard silver nitrate solution: dissolve 1.13 grams silver nitrate in distilled water and make up to 1 liter.
(4) Potassium iodide solution: dissolve 25 grams potassium iodide in distilled water and dilute to 100 cc.
(5) Citrate solution: 150 cc. concentrated C.P. ammonia, 120 g. citric acid, 200 g. C.P. ammonium sulfate, and add distilled water to make 1 liter.

To standardize the cyanide solution, pipet 10 cubic centimeters of the standard nickel salt solution into a 250-cubic centimeter beaker, add 50 cubic centimeters of the citrate solution, 2 cubic centimeters potassium iodide solution, and 5 cubic centimeters silver nitrate solution, and titrate with the cyanide solution until one drop just clears the cloudy solution resulting from the addition of the silver nitrate and potassium iodide solutions to the nickel. The factor for the cyanide solution is then obtained by dividing 8 by the number of cubic centimeters required in the titration.

To determine the concentration of a nickel-dip solution, about 100 cubic centimeters are taken from the tank and filtered through a dry filter paper to remove the sludge, discarding the first 10 to 20 cubic centimeters of filtrate. Ten cubic centimeters of the filtrate are then transferred by means of a pipet to a 250-cubic centimeter beaker, and 50 cubic centimeters of the citrate solution, 2 cubic centimeters potassium iodide solution, and 5 cubic centimeters silver nitrate solution are added. The addition of the silver nitrate to the potassium iodide causes a milky white precipitate to form in the filtered nickel solution. This precipitate acts as the indicator. The mixture is then titrated rapidly, cold, with the cyanide solution with constant stirring, until one drop of cyanide just clears the solution to a crystal-clear water-white or slightly yellow tint. The number of cubic centimeters required for this titration, multiplied by the factor obtained above, gives the concentration of nickel solution in ounces of single nickel salts per gallon.

In the titration, the cyanide reacts with the nickel present, continuing until this reaction has reached completion and then reacts with the silver iodide, dissolving it. Theoretically, the titration is slightly high, but there is so little silver present that it does not interfere with the accuracy required for ordinary control work.

The nickel solution must be titrated quite rapidly, and the end point should be anticipated by recognizing the point at which a few drops additional will cause the end-point to be reached, titrating drop by drop from this point until the final titration is complete. Experience and practice are of assistance in developing the proper technique, for the longer the time required to titrate the nickel solution, the higher will be the results, and variation in practice from day to day will lead to inaccurate results.

## X. Summary

Nickel dips, properly used, promote adherence of enamels to sheet iron or steel, and minimize or at least decrease fishscaling. Copperheading, in most cases, can also be controlled or decreased by such use.

The most successful operation entails solutions of 2 to 4 ounces per gallon concentration of single nickel salts, with $^1/_4$ ounce per gallon of boric acid as a "buffer" and close control of hydrogen ion concentration ($p_H$). Improper operation gives lessened advantages but probably causes little or no harm.

THE FERRO ENAMEL CORPORATION
CLEVELAND, OHIO

# MECHANICS OF ENAMEL SUSPENSION, II*
## The Electrodialysis of Some Enamels and Glasses

By R. M. King

Abstract

It is shown that it is possible to reveal reasonably small differences in the behavior of the various glasses when electrodialyzed. The results of electrodialysis agree fairly well with the tests and general knowledge of acid resistance.

### I. Introduction

Electrodialysis and its application to the study of soils and clays have been described by Mattson,[1] Bradfield,[2] and Terry.[3] Mattson[4] has shown that electrodialysis closely simulates the process of weathering. Hence it was considered desirable to study the general action of various glasses and enamels when electrodialyzed and also to study the relation between the results of this treatment and acid resistance, solubility, and the ease of "set-up" of the enamel. The results of studies on general behavior and its relation to acid resistance are reported here.

### II. Procedure

The Bradfield[5] analytical cell was employed in this work, but the procedure was somewhat modified to enable a base release-time curve to be obtained. This was done by discharging the alkaline dialysate into water acidified with accurately measured quantities of 0.1 *N* hydrochloric acid. Using rosilic acid as an indicator, the time was noted when the solution turned pink. A voltage of 125 across two cells was used.

The samples, with the exception of those from the Bureau of Standards, were ground to pass a 200-mesh Tyler sieve. The Bureau samples reported to be through 100-mesh screen were used as received. One gram of the ground sample was mixed with two grams of 46-mesh alkali-free Alundum grain, the purpose of which was to prevent cementing together of the glass particles. Preliminary tests showed that a 15-hour duration of the test was sufficient to differentitate between most of the glasses tested.

Acid-resistance ratings were obtained from three sources: (1) general experience, (2) the literature, and (3) the grain solubility test. This latter consisted of heating a 5-gram sample, ground to pass 40-mesh and retained on 48-mesh, in 20% HCl for 3 hours at 100°C, the sample being weighed before and after treating to obtain the weight loss.

### III. Materials Studied

The materials studied may be divided into three general classes: (1) commercial sheet-steel enamels, (2) commercial glasses, and (3) some special enamel glasses studied by Andrews.[6]

### IV. Results

Table I and Fig. 1 show the analytical data available and the results obtained.

### V. Discussion of Results

#### (1) General Behavior

In considering this factor the materials studied divide themselves into two groups: (1) those which release their bases rapidly and (2) those which release them comparatively slowly. Among the commercial enamels, the sheet-steel ground coat (C1) and cover coat (C2) have a release of five times as fast as the least stable acid-resisting enamel (C3). This in turn releases the base more than twice as rapidly as the other acid-resisting enamels (C4, C5, C6, C7, and C8).

---

* Presented at the Annual Meeting, American Ceramic Society, Buffalo, N. Y., February, 1935 (Enamel Division). Received February 19, 1935.

[1] Sante Mattson, "Electrodialysis of the Colloidal Soil Material and the Exchangeable Bases," *Jour. Agric. Research*, **33** [6] 553–56 (1926).

[2] Richard Bradfield, "An Inexpensive Cell for Purification of Colloids by Electrodialysis," *Ind. Eng. Chem.*, **20**, 79–80 (1928).

[3] G. E. Terry and R. M. King, "Mechanics of Enamel Suspension, I," *Jour. Amer. Ceram. Soc.*, **18** [5] 141 (1935).

[4] Sante Mattson, "The Laws of Soil Colloidal Behavior, XI. Electrodialysis in Relation to Soil Processes," *Soil Science*, **34** [2] 149–63 (1933).

[5] R. Bradfield, "A Simplified Cell for Determining the Electrodialyzable Base Content of Soils and Permutits," *Jour. Amer. Soc. Agron.*, **19** [11] 1015 (1927).

[6] A. I. Andrews, "Acid-Resisting Cover Enamels for Sheet Iron," *Univ. of Illinois Eng. Expt. Sta. Bull.*, No. 201 (1930).

TABLE I

CHEMICAL ANALYSES OF GLASSES

| Glass | $SiO_2$ | $B_2O_3$ | $Na_2O$ | $K_2O$ | CaO | BaO | PbO | MgO | $Al_2O_3$ | $Fe_2O_3$ | $As_2O_3$ | F | Acid-Resistance Rating: General | Acid-Resistance Rating: Electrodialysis |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pyrex-brand tubing | 80.75 | 12.00 | 4.10 | 0.10 | 0.30 | | | | 2.20 | | 0.40 | | Excellent* | 1 |
| Boron (Bur. Stand. 93) | 80.60 | 12.76 | 4.16 | 0.16 | | | | 0.026 | 1.94 | 0.076 | .14 | | | 1 |
| Lead barium (Bur. Stand. 89) | 63.35 | | 5.70 | 8.40 | 0.21 | 1.40 | 17.50 | .036 | 0.18 | 0.040 | .36 | | | 4 |
| Opal (Bur. Stand. 91) | 67.53 | | 8.48 | 3.25 | 10.48 | | 0.007 | | 6.01 | 0.081 | .102 | 5.72 | | 3 |
| Soda lime (Bur. Stand. 80) | 74.1 | | 16.65 | 0.04 | 4.65 | | | 3.23 | 0.33 | 0.65 | .07 | | | 5 |
| Soda-lime tubing | | | Unknown | | | | | | | | | | Good* | 2 |
| Glass electrode | 72.00 | | 22.0 | | 6.00 | | | | | | | | | |
| Durability committee | 73.27 | Present | 16.68 | | 4.85 | | | 3.30 | | 1.06 | | | | |
| **Enamel** | | | | | | | | | | | | | | |
| F3 | 55.00 | 12.7 | 17.0 | | | | 8.5 | | 6.8 | | | $CaF_2$ | Excellent† | 3 |
| F6 | 65.00 | 9.4 | 12.6 | | | | | | 8.0 | | | 5.00 | Excellent† | 4 |
| F17 | 45.1 | 24.6 | 12.3 | | | | | | 8.0 | | | 10.00 | Poor† | 6 |
| F19 | 53.3 | 12.3 | 16.4 | | | | 10.0 | | 8.0 | | | | Fair† | 5 |
| F28 | 60.0 | 11.8 | 15.2 | | | 5.0 | | | 8.0 | | | | Excellent† | 2 |
| F31 | 58.00 | 5.0 | 13.1 | | | | 15.9 | | 8.0 | | | | Excellent† | 1 |
| **Commercial Enamels** | | | | | | | | | | | | Loss (%) | | |
| Ground coat C1 | | | | | | | | | | | | | Poor* | 5 |
| Cover coat C2 | | | | | | | | | | | | | | |
| Acid-resisting C3 | | | | | | | | | | | | 0.95 | 6‡ | 4 |
| Acid-resisting C4 | | | | | | | | | | | | .28 | 3‡ | 3 |
| Acid-resisting C5 | Analysis not available | | | | | | | | | | | .15 | 2‡ | 2 |
| Acid-resisting C6 | | | | | | | | | | | | .44 | 5‡ | 1 |
| Acid-resisting C7 | | | | | | | | | | | | .08 | 1‡ | 1 |
| Acid-resisting C8 | | | | | | | | | | | | .37 | 4‡ | 2 |

* Estimated

† All F enamels, Andrews' ratings.

‡ Hydrochloric-acid solubility (C3–C8, inc.).

Among the special enamels, similar but even more marked results are found. Glasses like F6, F17, and F19 release their bases gradually early in the treatment. After an hour or so the glass seems to break down as it suddenly

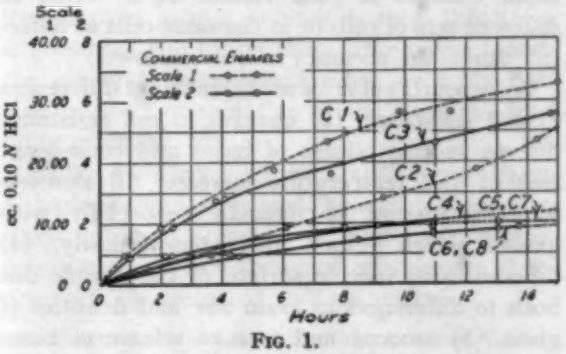



FIG. 1.

begins to release its base much more rapidly. This is accompanied by a marked increase in the current and temperature. This condition lasts for four or five hours and then the trend of the base release-time curve assumes a more constant but greater slope than at the beginning of the test.

During this rapid disintegration period a coarse precipitate is formed in the electrodialysis cell outside the retaining membrane. That precipitated from the commercial ground coat was found to contain a large proportion of silica. Mattson[7] has recorded the occurrence of a similar

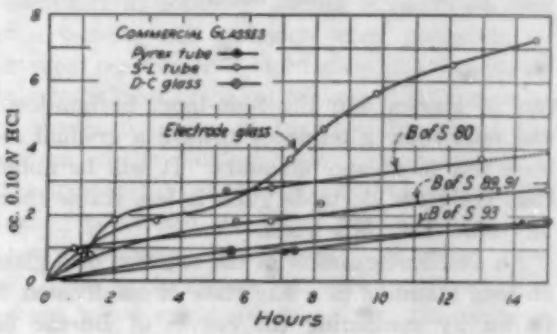



FIG. 2.

phenomenon when feldspar is electrodialyzed and explains it as follows: When the $p_H$ value of the sample becomes sufficiently low, certain complex alumino-silicate ions are formed and are

[7] Sante Mattson, "The Electrokinetic Behavior of the Alumino-Silicates," *Soil Science*, 25 [4] 289–311 (1928).

stable at this $p_H$. They are small enough to pass through the membrane as such but decompose on entering the alkaline solution outside the membrane and react with this solution to form silica and alumina.

Glasses F3, F28, and F31 are much more stable and hence release their bases comparatively slowly.

The glasses high in fluorides seem to be the least stable. F19 appears to be an exception to this.

Among the commercial glasses, the chemical ware glasses are found to release their bases very slowly and in small amounts, while the average

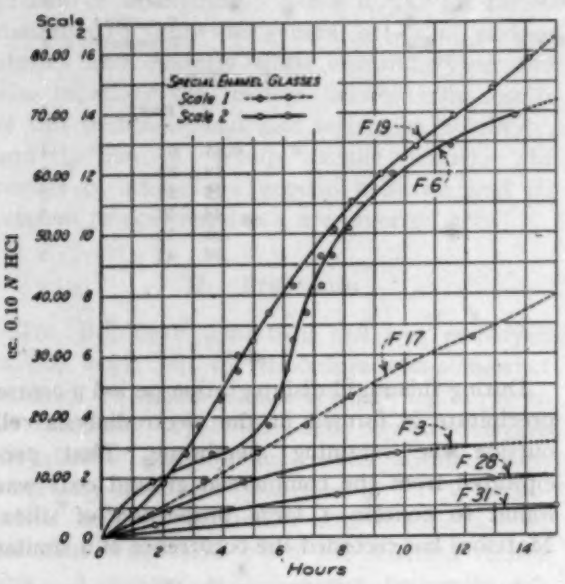



Fig. 3.

run of glasses like the soda-lime, barium-lead, and opal show a tendency toward a gradual release but in greater amounts. It will be noted that the glass electrode glass is less stable than any other soda-lime glass.

An excellent example of the reaction of a glass on long standing in a fine state of subdivision is shown by comparing the curves of Bureau of Standards No. 93 and that for Pyrex-brand tubing. The chemical analyses of these glasses are essentially the same as are the total amounts of base released by electrodialysis. The first cubic centimeter of acid, however, was consumed in about 50 minutes in the case of No. 93, while about seven hours were required in the case of freshly ground Pyrex-brand tubing.

## VI. Acid Resistance *vs.* Release of Bases

In Table I all glasses tested have been rated as to acid resistance in the light of data available and as to base release by electrodialysis. A rating of one indicates the best acid resistance and lowest base release, and as numbers increase the rating becomes lower.

Results from tests of individual commercial enamels show poor correlation, but general agreement is satisfactory, that is, those that show high base release also show high acid solubility and *vice versa*.

In the case of special enamels, ratings coincide in four cases and fail to agree in two cases.

The results obtained on commercial enamels agree with general experience and knowledge concerning these glasses, that is, the more chemically resistant the glasses are known to be, the more stable when electrodialyzed.

## VII. Discussion of Procedure

In the procedure followed, the most obviously necessary and most easily made refinements have been carried out. A study of the original notebook entries shows that an accuracy of from 3 to 10% of total base release is obtainable, depending upon the material, apparatus hook-up, special procedure, etc. If two samples of a glass of moderate base release were tested in two cells connected in series, the greatest accuracy was obtained. But if the glasses showed sudden and rapid changes in base release or if tested in different sets of cells or in the same cells at different times, the accuracy was much lower.

Some sources of error are (1) inherent differences in cell resistance, (2) changes in cell resistance due to sudden release of bases and consequent current and temperature increase, (3) slowness of color change of indicator, especially with glasses which release their bases slowly, (4) differences in specific surface of the sample due both to differences in grain size and densities of glass, (5) amount and rate of release of bases from the Alundum thimbles used as membranes, and (6) indefiniteness of end-points when titrating back to determine the total base released.

These sources of error are being studied and refinements are being made.

## VIII. Summary and Conclusions

Using electrodialysis as an accelerated weather-

ing process, certain differences have been shown in the manner and rate of glass and enamel disintegration.

On the whole the agreement between acid resistance and base release by electrodialysis is satisfactory.

Electrodialysis is suggested (1) as a possible method for determining glass durability, (2) for study of how glasses break down during weathering, and (3) for study of the influence of various ingredients on the stability of glasses.

A discussion of the accuracy of the method and sources of error has been given. The method as used has an accuracy of from 3 to 10% but is subject to refinement.

Department of Ceramic Engineering
Ohio State University
Columbus, Ohio

---

# SOME OBSERVATIONS ON THE ACTION OF STEAM ON GLASS*

By O. G. Burch

Abstract

The action of saturated steam on glass is apparently an action of superheated water. Filtration of saturated steam with partial removal of entrained water materially decreases the rate of decomposition of glass in contact with the steam, while dry steam has no apparent effect on glass. The decomposition of blown glass articles by saturated steam is influenced by the size, shape, and thickness of the articles and by their past history.

## I. Introduction

There are probably only two types of glassware which are subjected to the action of steam under pressure in the natural use of the articles. These types are (*a*) boiler-gage glasses and (*b*) glass containers, which are sterilized with steam before filling. Obviously, the best means of predicting whether a glass is suitable to withstand the action of steam satisfactorily is to expose it to a treatment similar to that which it must undergo in actual use. As a result of some irregularities arising in such testing, this paper is presented to caution those who may advocate the use of an autoclave method as a standard test for the determination of the chemical durability of glass.

Baillie,[1] Withey,[2] Turner,[3] and Rexer[4] have, at various times, discussed the merits of an autoclave test as a standard method for durability determinations, and they have made some of the observations presented in this study.

The work upon which the observations herein are based was undertaken as an attempt to ascertain reasons for the number of variable results obtained in commercial sterilization of glass containers. The resistance of bottles of the same glass composition to sterilization was found to vary considerably in a number of plants.

## II. Resistance Test

The method for testing the resistance of bottles to steam attack, in use in this laboratory, was essentially as follows: Bottles were rinsed, tied in a bundle with string or wire, placed in an inverted position on a wire rack which was placed in a cylindrical brass autoclave so that the necks of the bottles were about 12 inches above the surface of the distilled water in the autoclave. The temperature of the water was brought to the boiling point and the lid of the autoclave was closed, the steam being allowed to escape until all the air in the system had been removed. The escape valve was then closed and the pressure was brought to the desired point as quickly as possible. The time and pressure of the test were determined by the time and pressure of the sterilization process to which the bottles would be subjected in use, the pressure being the same as that commercially employed while the time was lengthened to twice the normal period. At the completion of the test, the pressure was re-

---

* Presented at the Annual Meeting, American Ceramic Society, Buffalo, N. Y., February, 1935 (Glass Division).

[1] W. L. Baillie, "Some Aspects of the Autoclave Test for Testing the Durability of Glass," *Jour. Soc. Glass Tech.*, **6**, 279 (1922).

[2] W. H. Withey, "Some Criticisms of the Autoclave as a Method of Testing Glassware," *ibid.*, p. 289.

[3] F. W. Hodkin and W. E. S. Turner, "The Action of Water and Steam under Pressure on Some Soda-Lime-Silica Glasses," *ibid.*, p. 291.

[4] E. Rexer, "A Critical Investigation of Methods for the Determination of Durability of Glass," *Keram. Rundschau*, **38**, 387 (1930); *Ceram. Abs.*, **10** [7] 486 (1931).

leased as quickly as possible and the bottles were removed and allowed to dry and cool in the open air, after which they were examined for visible disintegration of the glass. The autoclave and rack used in these tests is shown in Fig. 1.

### III. Observations of Irregularities in the Autoclave Tests

One interesting irregularity noticed in running autoclave tests on soda-lime glasses is the effect of substances such as string and blotting paper which are capable of taking up considerable amounts of moisture, enhancing the degree of

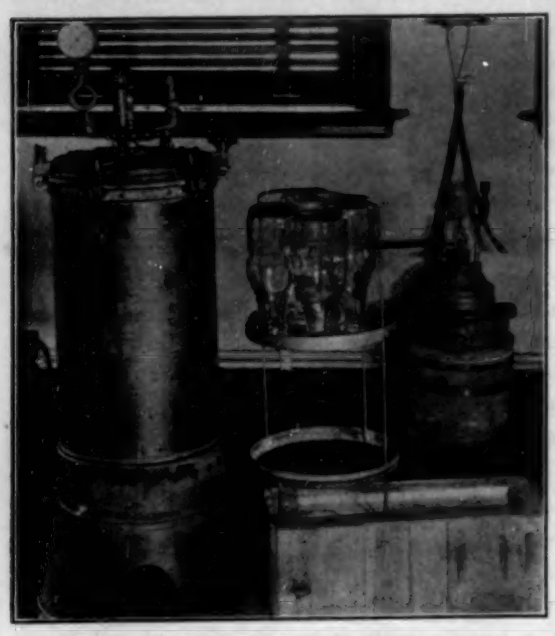


FIG. 1.—Autoclave and rack used in tests.

disintegration of glass with which they come in contact. The writer's attention was first called to this fact in binding a group of bottles together with string. The sections of the glass where the string touched the bottles were disintegrated to a greater degree than the other portions of the same bottles.

Figure 2 shows a bottle (No. 1) on which the effects of two narrow pieces of blotting paper fastened to the outer surface of the glass are clearly shown.

In contrast to this is the effect of other glass touching the outside of the bottles during the tests (Fig. 2, bottles Nos. 2 and 3). Bottle No. 2 shows a streak in the wall which remains clear as a result of another bottle contacting it during the test. Bottle No. 3 shows a streak of unattacked glass due to the fastening of a small strip of glass of the same thickness on the outside

1 2 3

FIG. 2.—Effect of other glass touching outside of bottles during tests: No. 1, 2 hr. at 2 lb. pressure; No. 2, 5 hr. at 30 lb. pressure; No. 3, 2 hr. at 20 lb. pressure.

of the bottle. This seems to indicate that the thickness of the bottle is a factor in the degree of attack undergone.

Although the writer has no absolute explana-

1 2 3

FIG. 3.—Containers, 8-oz. capacity; autoclave tests, 3 hr. at 60 lb. pressure.

tion of these phenomena, he believes that they are due to differences in the rates of condensation and evaporation of moisture on the inner walls of the bottles caused by different rates of heating

and cooling of the glass in contact with the string, paper, or glass, respectively.

### (1) Shape of Container

That the shape of the bottle or container is an appreciable factor in the degree to which the glass is attacked in the autoclave is evidenced in Fig. 3, which shows three bottles of the same glass composition and of the same capacity but of different shapes, after having been tested together for a period of 3 hours at a pressure of 60 pounds.

1 2

FIG. 4.—In autoclave, 2 hr. at 30 lb. pressure.

Another indication of the effect of the shape of the article on the results obtained is shown in Fig. 4. The cylinder, No. 1, was made by cutting from a bottle similar to No. 2. The two articles were rinsed and tested together for two hours at a pressure of 30 pounds.

1 2 3

FIG. 5.—Autoclave, 2 hr. at 20 lb. pressure: No. 1, 250 cc. capacity; No. 2, 100 cc.; No. 3, 29 cc.

### (2) Size of Container

That size as well as shape of the bottle affects the resistance of the glass to the action of saturated steam is shown in Fig. 5, which shows three bottles of the same composition and similar shape but of different sizes which have been subjected to two hours' treatment at a pressure of 20 pounds.

### (3) Age of Bottles

Figure 6 shows a photograph of two 16-ounce flasks of the same glass composition after an autoclave test of $2^1/_2$ hours at a pressure of 60 pounds. Flask No. 1 was three years old at the time of the test and No. 2 was tested on the date of manufacture. Both bottles were rinsed with water before being placed in the autoclave.

This result seems to indicate that a certain amount of alkali had been brought to the surface of bottle No. 1 with aging and that the rinsing at least partially removed this alkali, making the subsequent autoclave test of a less alkaline nature than was the case on the newly made bottle. This fact is further borne out in Fig. 7, which shows three 16-ounce round amber bottles after autoclave tests. The bottles were rinsed, placed in the autoclave together, and tested for a period of one hour at 20 pounds pressure. The bottles were then removed and allowed to dry. After drying, bottle No. 2 was rinsed and placed back in the autoclave with bottles Nos. 1 and 3, which were not rinsed. It seemed that the first test brought considerable alkali to the glass surface and that a great portion of this was rinsed from bottle No. 2, making the second

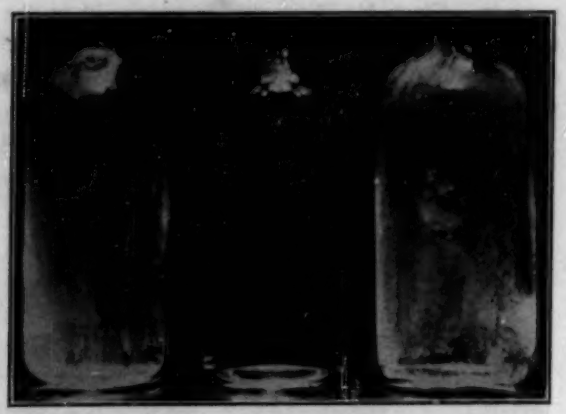
1 2

FIG. 6.—Autoclave, 2 hr. 30 min. at 60 lb. pressure: No. 1, 3 yr. old; No. 2, from leer.

test on this bottle of a less alkaline nature than it was on bottles Nos. 1 and 3.

## IV. Differences between Inside and Outside Bottle Surfaces

That the outside surface of glass bottles is more resistant to the action of saturated steam



1 2 3

FIG. 7.—Bottles after 2 autoclave tests of 1 hr. each at 20 lb. pressure: No. 2, rinsed between tests; Nos. 1 and 3, not rinsed between tests.

than the inside surface is shown in Fig. 8. The cylinder, which was cut from a 7-ounce round bottle, was subjected to an autoclave test at 35 pounds pressure for a period of five hours. All of the noticeable attack was on the inside surface of the cylinder. This difference in resistance is believed to be due to the rapid chilling of the outer surface by contact with the mold iron as contrasted to the slower air-cooling of the inner surface.

FIG. 8.—In autoclave 5 hr. at 35 lb. pressure.

## V. Effect of Entrained Water

During the investigation of the sterilization processes in use at various plants it was noticed that some of these plants loosely stoppered the bottles with cotton or porous caps. These plants found considerably less disintegration of the glass than did the writer in experimental tests on the same glass. In some plants where a steam jacket surrounded the sterilizer, there was no evidence of glass disintegration during sterilization. This difference in actual experience on the bottles in actual use and in this laboratory seemed to have been due to the fact that there was less entrained water entering with the steam in the plant practices.

1 2

FIG. 9.—Autoclave test, $1^1/_2$ hr. at 20 lb. pressure: No. 1, loosely stoppered with cotton; No. 2, neck left open.

For this reason the necks of some bottles were loosely stoppered with cotton and autoclave tests were then run on them. It was found that a bottle with no cotton stopper which showed an appreciable amount of attack in a 1-hour test at 20 pounds showed no visible disintegration in $2^1/_2$ hours at 20 pounds pressure when the neck was stoppered with cotton. This would seem to indicate that the attack of saturated steam on glass is initially an attack of superheated water followed by an attack which becomes increasingly alkaline in nature. Figure 9 illustrates the effect of loosely stoppering the bottle with cotton; the bottles are of the same chemical composition, No. 1 having been stoppered with cotton and No. 2, tested with the neck freely open. Both bottles were rinsed before testing. The test was run for $1^1/_2$ hours at 20 pounds pressure.

FIG. 10.—Apparatus for making tests.

## VI. Attack of Dry Steam on Glass

Having had an indication that a decrease in the amount of entrained water in the steam caused a less severe attack on the glass, it was thought that if all the water were eliminated from the steam, allowing only essentially dry steam to come in contact with the glass, little or no attack would be evidenced. The rather crude apparatus shown in Fig. 10 was used in making tests of this type.

The lower vessel served as the boiler or steam generator. The upper container was used as the dry steam chamber. This consisted of a hollow shell surrounded by electric heating elements over which was a thick layer of insulating material covered by an outer shell. By connecting a variable resistance in series with the heating elements, any desired temperature could be maintained within the dry steam chamber.

### (1) Method

The procedure employed in making the dry steam tests was as follows: The glass to be tested was rinsed and placed in the upper vessel which was then sealed. A definite volume of distilled water was placed in the generator and the lid was bolted in place. The current was turned on, and the temperature within the autoclave proper was raised slowly to 105°C. With all valves open, the flame was then placed beneath the steam generator. As soon as the air had been driven from the generator, the exhaust valve thereon was closed. With the valve between the two vessels open, the steam was allowed to escape from the autoclave until all of the remaining air in the system had been displaced. The exhaust valve on the autoclave was then closed, and the steam pressure was brought to the desired point, care being taken to keep the temperature in the autoclave 5°C above the theoretical temperature to eliminate water in the steam reaching the vessel. The pressure and temperature were maintained at the respective desired levels for the duration of the test, the flame was extinguished, and the steam was allowed to escape through the exhaust valve on the generator. When the pressure was reduced to atmospheric, the valve connecting the vessels was closed, the exhaust valve on the autoclave opened, and the heating current shut off. The autoclave was allowed to cool several hours and then opened and the subject glass removed and examined.

Figure 11 shows specimens of three compositions of window glass arranged so that each two successive plates are of identical compositions. Samples Nos. 1, 3, and 5 were subjected to the action of dry steam for a period of five hours at a pressure of 100 pounds, while Nos. 2, 4, and 6 were exposed to saturated steam for the same period at 100 pounds pressure.

Figure 12 shows the effect of exposure of a glass of relatively low durability to the action of dry steam for five hours at 100 pounds pressure as compared with the effect of exposure for 5 hours at 100 pounds to saturated steam. The bottles are of the same composition and each was rinsed before testing.

1 2 3 4 5 6

FIG. 11.—Tested 5 hr. at 100 lb. pressure: Nos. 1, 3, and 5, dry steam; Nos. 2, 4, and 6, saturated steam.

1 2

FIG. 12.—Tested 5 hr. at 100 lb. pressure: No. 1, dry steam; No. 2, saturated steam.

In an effort to determine quantitatively the effect of dry steam on decomposition of glass, the two bottles shown in Fig. 12 along with another bottle of the same kind, which was merely rinsed and dried in an electric oven for five hours at a temperature

of 175°C, were treated in the following manner: Allowed to cool, each bottle was partially filled with 450 cubic centimeters of distilled water. The necks were then stoppered with cotton, and the bottles were suspended in a water bath at a temperature of 90°C and maintained therein for a period of eighteen hours. The bottles were then removed, the contents of each were transferred to a Pyrex-brand glass beaker, each bottle being rinsed with two 50-cubic centimeter portions of hot distilled water, and the rinse waters were added to the respective solutions in the beakers. After cooling, the solutions were titrated with $N/50$ $H_2SO_4$ to a methyl orange end-point and the amount of sodium oxide leached from each bottle was computed.

### (2) Results

In the author's opinion, although the results may not show the actual difference in the degree of attack of dry and saturated steam, they do give some idea of that difference and show that

TABLE I

| | No. 1 Dry steam | No. 2 Saturated steam | No. 3 Dried in oven |
|---|---|---|---|
| $Na_2O$ (grams) | 0.0059 | 0.2362 | 0.0057 |

exposure to dry steam apparently has caused no more disintegration of the glass than has exposure to air at the same temperature for the same length of time.

## VII. Conclusions

In view of the foregoing data, the following conclusions seem justifiable:

(1) The resistance of glass containers to the action of saturated steam is affected by the sizes and shapes of the articles.

(2) The inside surfaces of bottles are more susceptible to attack by saturated steam than are the outside surfaces.

(3) The partial removal by rinsing of surface alkali present due to prolonged storage of bottles materially increases the resistance of the glass to the action of saturated steam.

(4) Decreasing the amount of water physically entrained in steam by filtration, decreases noticeably the action of the steam on glass.

(5) Dry steam apparently has no destructive action on glass.

(6) Inasmuch as dry steam does not attack glass, the action of saturated steam on glass must be one of superheated water.

(7) Unless the size, shape, and age of the article as well as the amount of moisture present in the steam are taken into consideration, autoclave tests are unsuitable as means for determining the durability of glass against the action of steam.

OWENS-ILLINOIS GLASS COMPANY
ALTON, ILLINOIS

# THE EFFECT OF TEMPERATURE TREATMENT ON GLASS-TO-METAL SEALS*

By J. T. Littleton

Abstract

It has been known for some time that glass cooled from temperatures well above the annealing temperature contracts at a rate depending upon its cooling rate and the temperature from which its cooling begins. Expansion measurements taken on the glass during later heating do not follow the original contraction curve. A photoelastic method is described which gives information on how the contraction of the glass is affected by these temperature conditions. The observations are of particular interest when applied to glass-metal seals.

## I. Introduction

It has been known for some time that the measured value of the expansion coefficient of any glass at high temperature is dependent upon the previous heat treatment of the sample and the rate of its heating during measurement. While it is possible to set up in the laboratory a set of reproducible temperature conditions and thus obtain reproducible measurements on the expansion coefficient of a glass, the values secured hold only for the particular set of temperature conditions used in the experiment. These measurements, whether taken at a series of constant temperatures or with falling or rising temperatures, specify exactly only the expansion phenomena for that particular set of temperature conditions. Measurements made on a carefully annealed and heat-treated sample of glass, having its temperature slowly and regularly increased or decreased during the course of the experiment, will not represent the changes in length in a sample of glass cooled at a different rate from the molten condition or cooled in air after a flame-working. The exact course of the contraction curve can not be inferred from data taken on samples of the glass having an entirely different temperature history.

Knowledge of the contraction coefficient of glasses is of great importance in problems involving sealing different glasses together or sealing glass to some other material such as a metal. The ability of the two materials to stay sealed together depends among other things upon the relative contraction coefficients of the two materials. The problem can not be entirely solved by selecting a glass and metal whose measured expansion coefficients agree, since the temperature conditions in laboratory-expansion measurements do not ordinarily agree with those used in the manufacturing process where the cooling rates are usually much more rapid. One of the chief obstacles encountered in measuring the contraction of the glass from high temperatures is the change in dimensions caused by flowing or warping. Since the absolute result depends upon the cooling rate, it is necessary to duplicate in the laboratory the cooling rate that is to be used in practice, and in quickly cooled ware the cooling is so rapid that the length and temperature changes can not be accurately followed. Since in these cases, however, our interest in the contraction of the glass is to determine the practicability of a given seal, it is simpler to make such a test by measuring photoelastically the stresses in the glass after a test seal has been made and from such measurements to evaluate the seal characteristics. The best cooling rate to produce a minimum stressed seal for a given combination can be easily determined in this manner. Since the measured stress is characteristic of the particular thermal history of the sample, it becomes possible to change the stress by a modification in heat treatment and to select the treatment required to give minimum stressed seals.

It is the purpose of this paper to describe the optical equipment for making such measurements and to illustrate the effects of heat treatment on the strain in glass-to-metal seals by means of some observations on a number of test seals.

## II. Experimental Equipment

The stress in the glass along the seal is measured by means of a quartz-wedge compensator. This instrument is well known and the details of its operation have been described in most of the

* Presented at the Annual Meeting, American Ceramic Society, Buffalo, N. Y., February, 1935 (Glass Division).

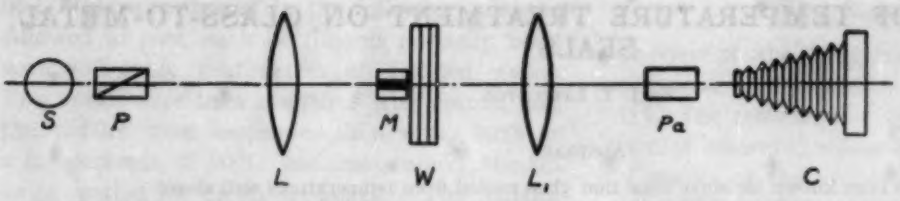



FIG. 1.—Schematic drawing of optical equipment: *S*, source; *P* and *Pa*, polarizing and analyzing Glan-Thompson prisms, crossed; *L*, collimating lens; $L_1$, field lens; *M*, glass-to-metal seal; *W*, quartz wedges of compensator, *C*, camera.

standard textbooks on optics. Figure 1 shows a schematic drawing of the optical equipment.

The compensator used was made up of a system of three pairs of quartz wedges giving an effective retardation of 89.6 mμ per millimeter of wedge length. The combination of three pairs of wedges was by no means essential, their use being due to the fact that by this combination greater sensitivity could be obtained than by the use of any single pair of wedges immediately available.

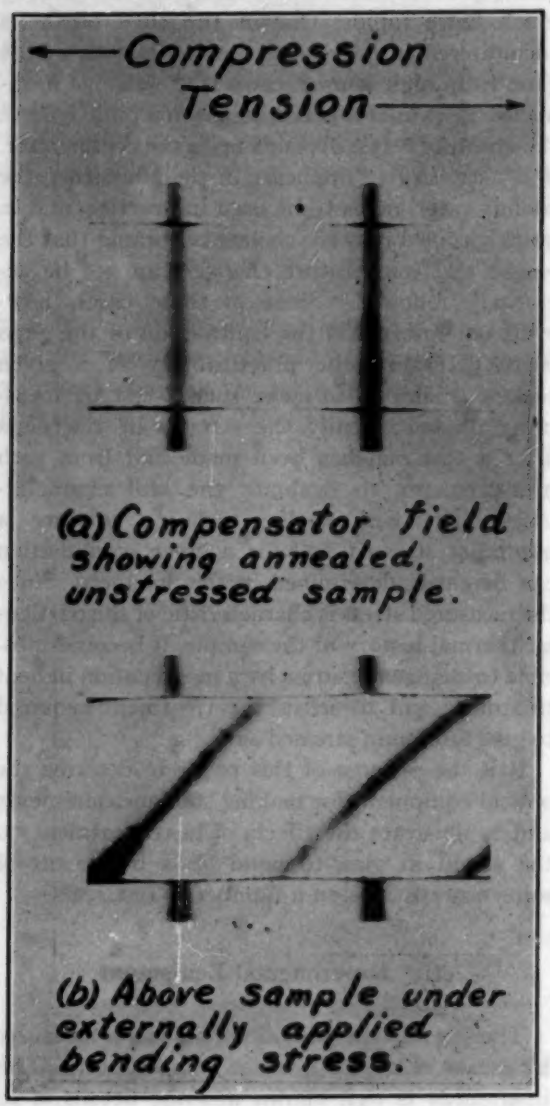

Compression
Tension
(a) Compensator field showing annealed, unstressed sample.
(b) Above sample under externally applied bending stress.

FIG. 2.

The test sample was prepared by covering the metal strip with a rather thick layer of glass and then by grinding the glass to form a rectangular sandwich with the edges of the metal strip exposed. The glass plates were initially about one-half inch wider than the metal strip. The edges and faces of the glass were then polished. The finished samples were 6.3 millimeters in width. The observations were made with the long dimension of the strip perpendicular to the line of sight and looking through the strip parallel to the metal surface. In this position the stress in any plane parallel to the metal is practically uniform across the plane so there is no appreciable difference between the average stress and the maximum stress; hence the maximum stress can be measured. Due to the manner in which the samples were prepared and to the characteristics of the optical system, the only stresses in the system measured are those stresses parallel to the metal face and perpendicular to the line of sight. Therefore the stress measured is that caused by the differential contraction in length of the glass and metal.

When unstrained glass is interposed between the polarizer and the compensator the original parallel dark lines in the field of view of the observer are unaffected. If a sample of strained glass be interposed, then the lines are displaced from their original position and the displacement is proportional to the stress. This method of stress analysis has been explained before[1] and need not be considered in detail here. It is sufficient to state that a displacement in one direction indicates tension, and in the other direction it indicates compression. In Fig. 2 are shown photographs of an annealed glass and of the same glass under a bending stress. The slanting lines represent the stress distribution curve in the glass

[1] J. T. Littleton, *Phys. Rev.*, **22**, 510 (1923).

due to the bending load. The sample is in compression on the lower side and in tension on the upper side. Hence, a displacement of the black lines to the left means compression and to the right, tension.

### III. Experimental Results

Observations were made on a series of three glass and metal combinations. Figure 3 shows the expansion curves of the glasses and metals

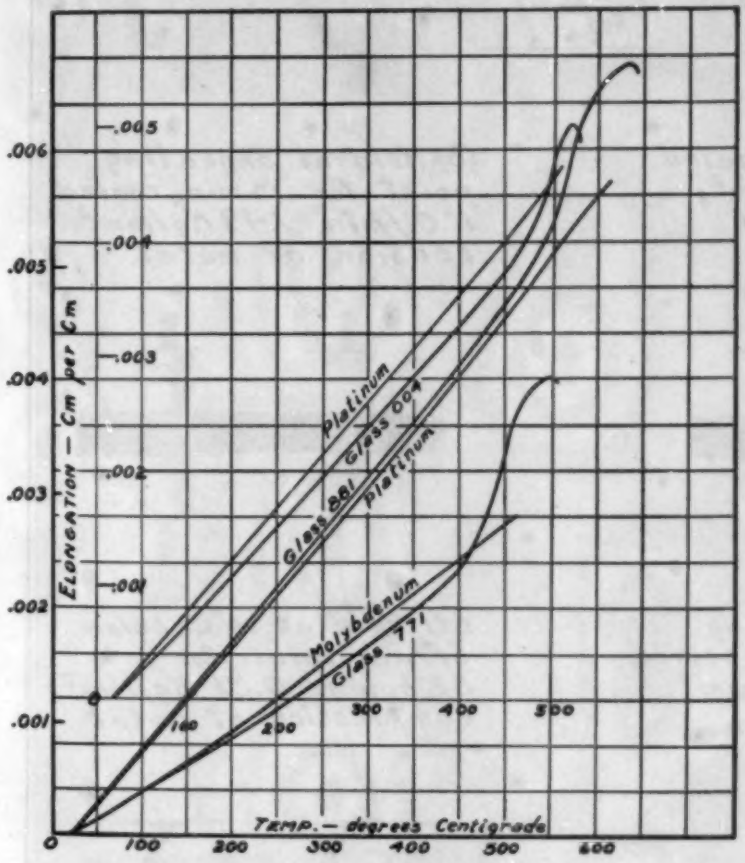



FIG. 3.—Thermal expansion curves of glasses and metals.

obtained in the usual manner. The glass samples were held for fifteen minutes at the annealing point and then cooled at a rate of about one degree per minute. Expansion measurements were made at a heating rate of one degree per minute.

Figures 4, 5, and 6 show how the stress along the seal is affected by the heat treatment of the sample. It is at once apparent that in order to get an exact match between glass and metal a precise heat treatment of the sample must be specified.

In Fig. 4 are shown seals of glass 881 to platinum. For rapid cooling, the glass contracts more than does the metal; hence it is in tension. Even a cooling of $^1/_2$ degree per minute does not completely eliminate this tension. But a 32-hour treatment at 10° below the strain point has shifted this tension to compression. A 15-minute treatment at the annealing temperature has partially neutralized this compression.

Figure 5 shows a glass and metal in which the best match is obtained by a rapid cooling. The glass has normally a lower expansion coefficient than the metal; hence it is under compression, and heat treatment at low temperatures increases this compression.

The combination shown in Fig. 6 gives the best match at some heat treatment between those shown in (*a*) and (*b*).

Hull and Burger[2] have recently given in detail a complete description of the physical factors involved in glass-to-metal seals. They have shown how, from photoelastic measurements similar to those described here, the stresses in glass rods may be evaluated, and they have made comparisons between such measurements and those computed from a knowledge of the physical constants of glass and metal. Their measurements are in good agreement with the computations if the computations are made on glass seals having the same thermal history as that of the samples from which the physical constants are determined. The photoelastic method has the intrinsic advantage of giving directly the desired information without the necessity of making allowances for possible differences in heat treatment.

### IV. Conclusions

Strain-free glass-to-metal seals can be obtained only by proper heat treatment characteristic

[2] A. W. Hull and E. E. Burger, *Physics*, **5**, 384 (1934).

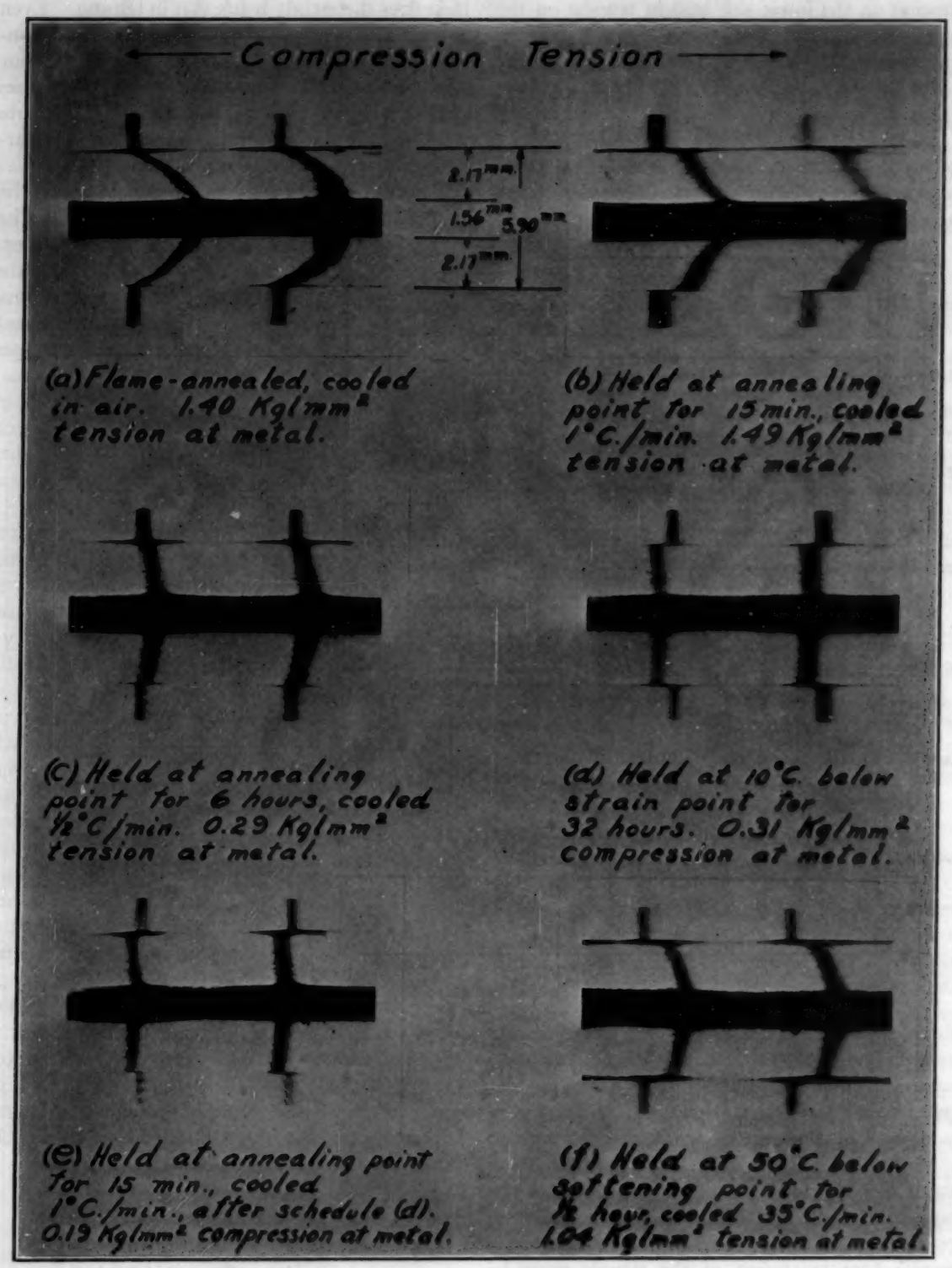

Compression
Tension
2.17 mm.
1.56 mm
5.90 mm
2.17 mm.
(a) Flame-annealed, cooled in air. 1.40 Kg/mm² tension at metal.
(b) Held at annealing point for 15 min., cooled 1°C./min. 1.49 Kg/mm² tension at metal.
(c) Held at annealing point for 6 hours, cooled ½°C/min. 0.29 Kg/mm² tension at metal.
(d) Held at 10°C. below strain point for 32 hours. 0.31 Kg/mm² compression at metal.
(e) Held at annealing point for 15 min., cooled 1°C./min., after schedule (d). 0.19 Kg/mm² compression at metal.
(f) Held at 50°C. below softening point for ½ hour, cooled 35°C./min. 1.04 Kg/mm² tension at metal.

FIG. 4.—Glass No. 881 sealed to platinum; softening point 702°C, annealing point 536°C, strain point 503°C.

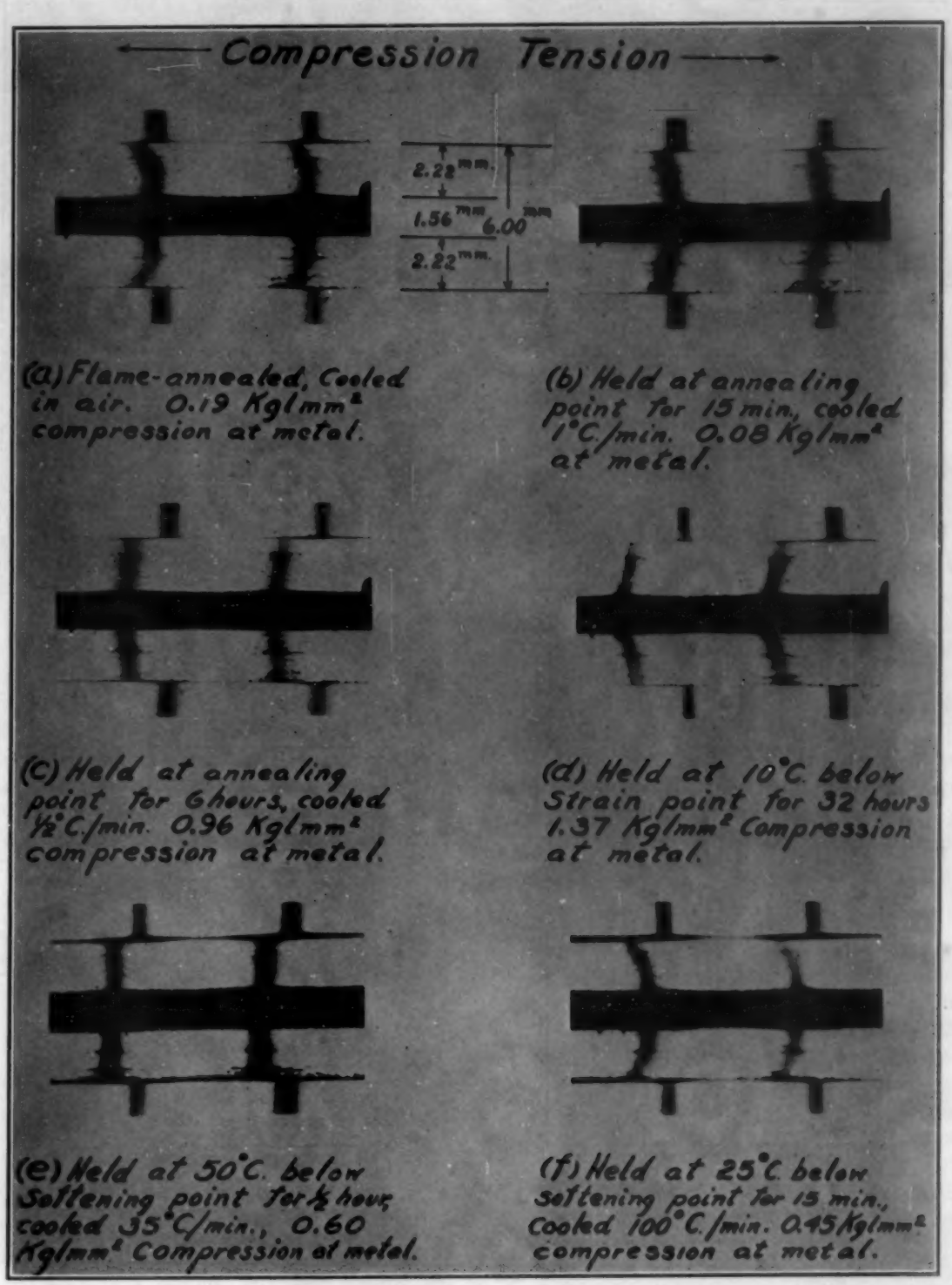

Compression Tension
2.22 mm.
1.56 mm
6.00 mm
2.22 mm.
(a) Flame-annealed, Cooled in air. 0.19 Kg/mm² compression at metal.
(b) Held at annealing point for 15 min., cooled 1°C./min. 0.08 Kg/mm² at metal.
(c) Held at annealing point for 6 hours, cooled ½°C./min. 0.96 Kg/mm² compression at metal.
(d) Held at 10°C. below Strain point for 32 hours 1.37 Kg/mm² Compression at metal.
(e) Held at 50°C. below Softening point for ½ hour, cooled 35°C./min., 0.60 Kg/mm² Compression at metal.
(f) Held at 25°C. below softening point for 15 min., Cooled 100°C./min. 0.45 Kg/mm² compression at metal.

FIG. 5.—Glass No. 004 sealed to platinum; softening point 643°C, annealing point 452°C, strain point 419°C.

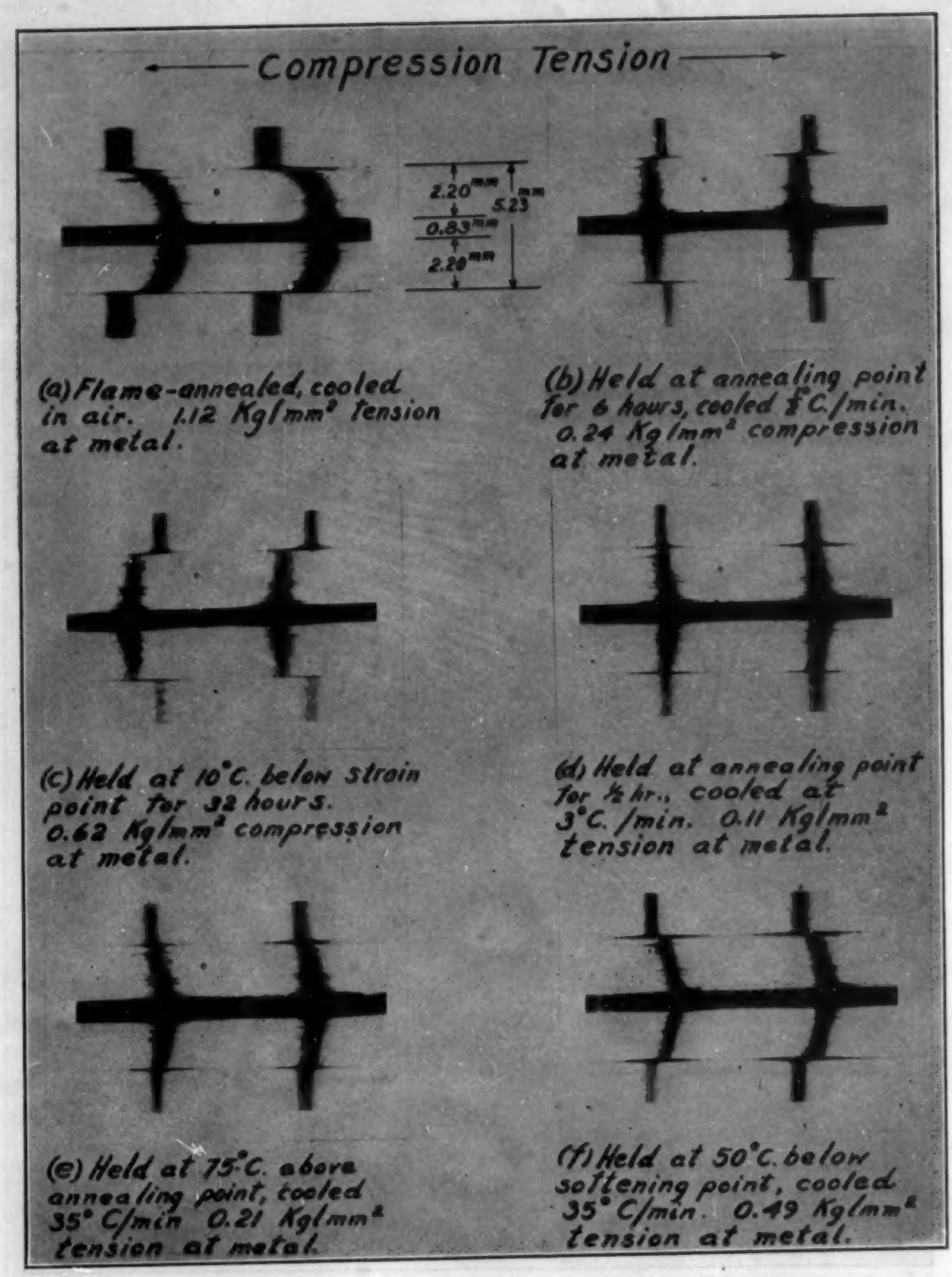

Compression Tension
2.20 mm
5.23 mm
0.83 mm
2.20 mm
(a) Flame-annealed, cooled in air. 1.12 Kg/mm² tension at metal.
(b) Held at annealing point for 6 hours, cooled 2°C./min. 0.24 Kg/mm² compression at metal.
(c) Held at 10°C. below strain point for 32 hours. 0.62 Kg/mm² compression at metal.
(d) Held at annealing point for ½ hr., cooled at 3°C./min. 0.11 Kg/mm² tension at metal.
(e) Held at 75°C. above annealing point, cooled 35° C/min 0.21 Kg/mm² tension at metal.
(f) Held at 50°C. below softening point, cooled 35° C/min. 0.49 Kg/mm² tension at metal.

FIG. 6.—Glass No. 771 sealed to molybdenum; softening point 705°C, annealing point 513°C, strain point 479°C.

of a given combination. The best heat treatment can be determined by photoelastic measurements on a series of seals having varied thermal histories. The amount and character of the strain in such seals can be controlled to an accurate degree by means of the heat treatment. Heat treatment of the glass sample near its strain point decreases the contraction of the glass, while quick cooling from the annealing point or above increases the contraction.

**Acknowledgment**

The author is indebted to Guy E. Stong and W. W. Shaver of this laboratory for preparing the glass-metal samples and for the photographs of the stress distribution.

PHYSICAL LABORATORY
CORNING GLASS WORKS
CORNING, NEW YORK

---

# MORTARS SUITABLE FROM THE STANDPOINT OF WATER-TIGHTNESS IN UNIT MASONRY*

BY L. A. PALMER

ABSTRACT

This paper deals with results obtained in the leaky masonry study at the National Bureau of Standards. Possible improvements in test procedures in future investigations are indicated. The relative importance is shown of mortar properties on the one hand and brick properties on the other as they are concerned either with causing or preventing leaky masonry.

## I. Important Variables Overlooked in Laboratory Tests

### (1) Wetting Brick

Different "standard procedures" of wetting brick in assemblage tests have been adopted in different laboratories, but a standard procedure of brick wetting can not be followed in actual construction. Test assemblages should be constructed with some of the brick under-wetted and some over-wetted, just as takes place when brick are laid in buildings.

Considering the practical aspects of brick wetting on the job, the following excerpt from a paper by W. C. Voss, published in the 1934 Year Book of the New England Officials Conference, Inc., is most enlightening.

"4A. In this combination we have the other extreme from 1A. Here the brick robs the mortar of a great deal of its water and reduces it to a granular state, not only causing a great tendency toward porosity in the mortar but weakening it to such an extent that it no longer serves its purpose. We often try to get around this predicament by wetting such brick. If these brick are just hosed down in a pile, picture the thousands of variable behaviors in an ordinary wall. See the joint crumbling in some places, sagging in others, light colored here, dark gray there. A terrible remedy to be sure. Devoid as this mortar is of a 'healing' constituent, this combination becomes the worst of all."

The combination, 4A, referred to by Voss, is a high Portland cement low lime content mortar applied to a very porous, soft, and rapidly absorptive brick. Voss blames the combination, rather than the type of brick. In the next paragraph of his paper he states that if such brick must be used, and they are satisfactory for backing-up, a high lime mortar is the only answer.

A mortar of very high water-retaining capacity should be used with fast-absorbing brick. The mason, however, must be told what mortar to use to get a good job. Voss has supplied the information in understandable terms.

### (2) Workmanship as Influenced by Mortar Properties

Few persons have appreciated the simple fact that the work of the mason is almost entirely dependent on mortar properties. Few realize that the modern use of harsh-working, rapidly stiffening mortars promotes habitual neglect on the part of masons to shove brick into place. When this habit of neglect is formed, it may persist long after the mason is provided with more workable mortars. The failure to fill head joints in walls properly has developed through over-promotion and over-use of poorly workable and dense cement mortars of high strength.

If, on the job, only enough mortar is spread at one time to bed a single brick, and good pressure is exerted in laying the brick, and if the mortar is pressed into vertical joints with the tip and edge of

* Presented at the Annual Meeting, American Ceramic Society, Buffalo, N. Y., February, 1935 (Structural Clay Products Division). Received February 27, 1935.

the trowel, the cost of building will be materially increased. When, however, this procedure is used in the laboratory, poorly workable mortars get a higher rate than they deserve. The results mislead to the belief that high strength in mortar insures high strength in masonry, a condition not usually realized. Strong mortars often serve only to hold brick apart rather than together. Any procedure that minimizes the importance of mortar workability is one that yields results which, by inference or otherwise, assign to the brick more blame for leaky walls than is their due.

The small difference in time elapsing from the instant that mortar is spread on a brick until it is covered with a top brick is important. Mortars of low water-retaining capacity tend to segregate (bleed) when left uncovered on a course of brick incapable of absorbing much water because of low absorption or of saturation by wetting. This is an important consideration. The mason usually spreads enough mortar at one time to bed four or five brick. Segregation, therefore, is inevitable in practice when poorly workable mortars of low water-retaining capacity are applied to brick of low porosity or to brick that have been carefully saturated.

Segregation under these conditions was especially noticeable in the construction of beams for transverse-strength tests. Wherever puddles of water collected there was no adhesion of the mortar to the brick. Probably no bricklayer or inspector on the job would ever notice the puddles or water-pockets in the mortar bed. With mortars of high water-retaining capacity such segregation is not in evidence even to the careful observer.

Mortars that segregate in the manner described usually undergo relatively high volume changes subsequent to hardening. Whether or not the reason for the association of these two undesirable properties is known, the fact remains that the one is usually the accompaniment of the other. Mortar segregation causes poor initial contact resulting in poor distribution of bond or adhesion which, in turn, leads to excessive water transmission. The excessive wetting of the wall accelerates volume changes in mortar which has a natural tendency to undergo high volume changes. The final result is that the masonry leaks at the outset and the imperfect adhesion of mortar to units tends to be completely destroyed. All of this happens with mortars of high strength, mortars which have excellent records in laboratory freezing and thawing tests.

In Table I, the results of the beam tests (recorded in Table 13 of the paper by Palmer and Parsons[1]) are computed in terms of bonding efficiency of the mortars.

TABLE I

$$\text{Bonding Efficiency of Mortars} = \frac{\text{Av. Modulus of Rupture of Beams}}{\text{Av. Modulus of Rupture of Mortar Slabs}} \times 100$$

Bonding Efficiency of Mortars at 3 months, porous brick Nos. 1, 2, 4, and 6 laid wet

| Mortar designation | Mortar composition by volume | With brick No. 1 (%) | With brick No. 2 (%) | With brick No. 3 (%) | With brick No. 4 (%) | With brick No. 5 (%) | With brick No. 6 (%) | Average (%) |
|---|---|---|---|---|---|---|---|---|
| AI | 1PC:3S | 11.0 | 44.1 | 8.3 | 21.3 | 3.9 | 0.0 | 14.8 |
| XTd | 0.15L:1PC:3S | 3.1 | 20.5 | 6.0 | 19.5 | 0.6 | 23.1 | 12.1 |
| XRa | 1L:1PC:6S | 38.0 | 44.8 | 49.3 | 60.7 | 10.6 | 70.3 | 45.6 |
| XVa | 1L:1PC:6S | 25.8 | 28.7 | 41.1 | 53.6 | 4.1 | 74.0 | 37.9 |
| XVb | 2L:1PC:9S | 38.2 | 35.6 | 33.8 | 70.7 | 9.0 | 75.2 | 43.8 |
| XRc | 3L:1PC:12S | 27.3 | 22.2 | 28.0 | 32.1 | 14.0 | 38.6 | 27.0 |
| CII | 1L:3S | 24.2 | 27.3 | 33.3 | 22.7 | 11.0 | 27.9 | 24.4 |
| BI | 1MC:3S | 4.7 | 23.0 | 7.8 | 27.4 | 1.2 | 0.1 | 10.7 |
| BIII | 1MC:3S | 12.7 | 26.8 | 21.1 | 21.9 | 2.0 | 11.6 | 16.0 |
| BIV | 1MC:3S | 0.0 | 36.3 | 20.0 | 3.9 | 1.7 | 0.1 | 10.3 |
| BVI | 1MC:3S | 37.4 | 33.2 | 62.9 | 56.8 | 19.4 | 62.8 | 45.4 |
| BXI | 1MC:3S | 2.5 | 10.1 | 12.5 | 13.6 | 0.5 | 15.5 | 9.1 |

L = lime MC = masonry cement PC = Portland cement S = sand

The data of Table I were obtained with a careful procedure of wetting the porous brick, Nos. 1, 2, 4, and 6; brick No. 5 was extremely impervious; No. 3 was also very impervious but not as extreme as No. 5. The bonding efficiencies of all mortars were low with brick No. 5, although in tests for water-tightness this brick had the best record of all of the six types of brick when laid up with these same mortars.

Bonding efficiency depends on the extent and intensity of adhesion. Brick No. 5 was satisfactory in the water-tightness tests because good

[1] L. A. Palmer and D. A. Parsons, "Study of Properties of Mortars and Brick and Their Relation to Bond," *Bur. Stand. Jour. Research*, **12** [5] 609–44 (1934); R.P. 683.

extent of adhesion was easily obtainable with it and workable mortars and because good extent of bond was obtained with brick No. 5 and the poorly workable mortars, in making assemblages for water-tightness tests (not the beams of Table I). Every possible care and precaution was taken to overcome the handicap of poor mortar workability by working rapidly, laying one brick at a time, allowing no time for mortar segregation and packing all joints tight in making the permeability specimens. These precautions ("standard procedures") yielded results with this brick that are absolutely not in agreement with practical experience when a poorly workable mortar that segregates is used. The possible conclusion that a brick lacking in suction provides water-tight walls with *all types* of mortars is thoroughly unsound in view of the fact that the variable, workmanship, was improved to such a point, by extra effort, that it ceased to be a factor in the permeability tests. Yet this conclusion was derivable from the data of Table III of the paper, "Permeability Tests of 8-Inch Brick Wallettes."[2]

The same statements may be made with reference to the water-tightness tests with porous brick Nos. 1, 4, and 6 laid wet. The results recorded in Table III of the A.S.T.M. paper might be interpreted as meaning that a relatively dry wall may be obtained with any mortar and porous brick that is properly wetted when laid. This alibi for harsh-working mortars is decidedly unfair to brick. If the reader senses the futility of "properly" wetting porous brick in actual practice, he may conclude that only brick of low absorption should be used. If his conclusions were written into specifications, they would be detrimental to the interests of all users since, on this basis, any type of mortar would be used and the game of guessing would go on as the new structures develop leaks. Moreover, a great many satisfactorily performing porous brick would become unpopular. The whole situation would be manifestly unfair to producers of structural clay products. All of this can easily come about through laboratory results which are the fruit of certain "standard procedures" that eliminate most worthy factors from consideration. The laboratory procedure has attempted to eliminate all defects in masonry that are directly traceable to poor workability of mortar by getting as far away from practicable working conditions as possible. In the future, laboratory procedures should parallel field practice.

Table I indicates the divergence in results obtained with different mortars when the time element in laboratory bricklaying more closely approximates that in actual building than was the case in any other tests made in the leaky masonry study at the National Bureau of Standards. Except for the fact that the brick were more carefully and "properly" wetted than would ever be the case on an actual building job, the conditions in these laboratory beam tests (Table I) should compare favorably with those obtaining in actual building practice where there is strict supervision and inspection of the work of masons.

It is obvious that mortars XRa, XVa, XVb, XRc, CII, and BVI were more adaptable to a diversity of brick than the other mortars of Table I. Bonding efficiency is dependent on two things: (1) the extent or distribution of adhesion and (2) the intensity of adhesion. The extent of adhesion obtained with mortars XRa and XVa, although not complete, was yet comparatively good, a great improvement over that obtained with mortars AI and XTd. The extent of bond obtained with mortars XVb, XRc, and BVI was practically complete with all brick. With mortars XVb, XRc, and BVI only, the two conditions, complete extent of bond and relatively good intensity of adhesion, were combined. The relatively low bonding efficiencies of mortars BI and BXI (modified natural cements) were due to but one thing, *i.e.*, to the low intensity of adhesion of these mortars to brick. The extent of adhesion with these two mortars was good as indicated by the relative degree of water-tightness obtained with test walls built with them.

Mortars AI, XTd, and BIV of high strength are of the type that provide leaky walls of uncertain strength. Mortars of type XRa and XVa are the best for wall strength in flexure[1] but not from the standpoint of water-tightness. Their high intensity of adhesion more than compensates for the small extent of unbonded areas through which water can pass. Mortars XVb, XRc, and BVI provide the best combinations of masonry (not mortar) strength and water-tightness with all brick. Mortar CII (masons' hydrated lime) is comparatively weak in tension but rates well on the basis of water-tightness since it provides good extent of bond. Mortar BIII is an improvement over BIV, AI, and XTd but like these mor-

[2] Proceedings A. S. T. M., Vol. 34, Part II (1934).

tars is lacking in workability and water-retaining capacity. Its lower volume changes subsequent to hardening account for the fact that its lowest bonding efficiency was 11.6%, whereas minimum values for mortars AI, XTd, and BIV were 0, 3.1, and 0%, respectively.

The extent of adhesion of brick No. 5 in the beams (Table I) is complete with mortars XVb, XRC, and BVI, as with the other five brick. With the right mortar, there is no trouble in getting water-tight walls with an extremely impervious brick of type 5. The intensity of adhesion, however, is generally low with a brick of this type. This is due to a certain brittleness of bond at the juncture of brick and mortar. Ordinarily, in the absence of an earthquake or severe vibration, this condition should give no trouble. If a poorly workable mortar of high volume change after hardening is used with a brick of type 5, then water, entering through partially filled joints and separation cracks between mortar and brick, is not retained in the wall but passes on through and into the interior. No mortar that segregates and forms water-pockets should ever be used with this brick.

Brick Nos. 3 and 5 were laid dry in the beam tests. The absorption of brick No. 3 was very low but somewhat higher than that of No. 5.

Table II contains those data from water-tightness tests which were obtained under conditions wherein there is good reason to believe that mortar workability was of relatively more importance in controlling water-tightness of masonry than was the case in the other tests. Brick No. 2 (laid wet) was rough-surfaced. The more plastic mortars worked into and filled the surface indentations, whereas the less workable mortars bridged across such areas. Brick No. 1 (laid dry in the water-tightness (tests) was a fast-absorbing dry-press brick which quickly withdrew water from mortars of low water-retaining capacity.

The average bond strengths at 3 months (all brick laid dry) of the ten mortars in the order listed in Table II were 14.6, 14.3, 31.0, 22.9, 27.0, 42.8, 17.3, 17.3, 21.9, and 45.0 pounds per square inch, respectively.

It is significant to note that in the last columns of Tables I and II, with data obtained under two entirely different sets of conditions, any mortar having a high bonding efficiency under one set of conditions (Table I, porous brick laid wet) had also a correspondingly high bonding efficiency under the other set of conditions (last column of Table II, all brick laid dry). This fact should be borne in mind by those who advocate brick-wetting as a method of minimizing defects in masonry that are traceable to mortars of poor adaptability to a diversity of brick.

TABLE II

MORTAR WORKABILITY AS AFFECTING WATER-TIGHTNESS OF MASONRY

| Mortar | Workability rating | Average maximum rate of water transmission through test walls (averages for 3 wallettes) | | Average bonding efficiency of mortars; all brick laid dry (%) |
|---|---|---|---|---|
| | | Brick No. 2 laid wet (ml./min.) | Brick No. 1 laid dry (ml./min.) | |
| BI | Excellent | 39 | 77.5 | 8.5 |
| BXI | Excellent | 44 | 95.0 | 12.1 |
| XVb | Excellent | 40 | 128.0 | 26.3 |
| XRc | Superior | 26 | 98.0 | 21.0 |
| BVI | Superior | 15 | 94.0 | 24.8 |
| XRa | Good | 43 | 386.0 | 25.0 |
| CII | Fair | 36 | 178.0 | 20.4 |
| BIII | Poor | 97 | 317.0 | 11.0 |
| BIV | Very poor | 138 | 626.0 | 11.9 |
| XTd | Very poor | 226 | 402.0 | 7.0 |

The per cent bonding efficiency is not a good index to water-tightness. This is evident from a consideration of mortars BI, BXI, and XRa of Table II. The intensity of adhesion has no effect on water-tightness as long as the extent of bond is complete or nearly so. A high bonding efficiency tends more to indicate the existence of a good combination of masonry strength and water-tightness.

The magnitude of the values of Table II, column 4, are inversely proportional to the respective water-retaining capacities of the different mortars. Water-retaining capacity is a good index to workability.[4]

[4] The water-retaining capacities as well as the data for other properties of the mortars of Tables I and II are given in a data supplement to Bureau of Standards Research Paper No. 683, obtainable from this Bureau on request.

Mortars of the type XVb, XRc, and BVI are considered as most suitable from the standpoint of both water-tightness and masonry strength.

### (3) Exposure of Laboratory Specimens

The weather resistance of a masonry wall depends upon two things: (1) the extent to which the wall becomes and remains saturated, and (2) the weather resistance of the separate materials, building units, and mortar.

The first factor is more important by far than the second. A comparatively dry wall is more frost-resistant than a very wet wall regardless of the frost resistance of the materials composing either wall. The splendid records of dense cement mortars in laboratory freezing and thawing tests are therefore misleading. We do not get a dry wall by selecting materials that are frost-resistant in a very wet wall. Usually such materials lack the properties that are conducive to the attainment of a dry wall. Disintegration through frost is symptomatic of over-saturation of the wall. There may be over-saturation and wet interiors of buildings without this symptom, disintegration. (If we know what we are about we shall treat the cause, not the symptom.)

Similarly, efflorescence is another symptom of too much water in the wall. Selecting materials that contain no soluble salts is treating the symptom rather than its cause. Disintegration, efflorescence, and wet interiors of buildings disappear as symptoms when the real evil is eradicated, *i.e.*, too much water in masonry walls; this is effected mainly by an intelligent selection of mortar materials.

Laboratory freezing and thawing tests, as usually conducted, do not indicate the comparative degree of frost-resistance of different materials. Some natural cements, hydraulic limes, and limes are slow in attaining their ultimate strengths. To subject such materials to a large number of freezing and thawing tests prior to their having attained any reasonable percentage of their ultimate strength is again avoiding realities. Such heroic tests with brick, that are not likely to increase in strength or to develop greater weather resistance with passage of time, may possibly have some meaning. The procedure may also be applicable when used with eminently hydraulic cements such as Portland.

A study of the frost resistance of mortars by repeated thawing of frozen mortar specimens is of little value, because the excessive dampness, characteristic of this type of treatment, would likely cause the building to become uninhabitable long before disintegration from freezing and thawing is in evidence.

Furthermore, there is no relation between results obtained by curing mortar specimens under water or in a damp closet and the properties of mortars between building units in a wall. Yet present A.S.T.M. and federal specifications for masonry cement require this method of curing mortar specimens. If the wall is to remain comparatively dry, it is difficult to see any reason for tests which can be favorable only to eminently hydraulic materials. The results of tests involving continuously damp curing of mortars would have some bearing on the subject if the masonry wall is to serve as a dam or reservoir.

Very few persons, however, doubt the superiority of concrete for construction that is to be continually in contact with water. If brick walls are built in the hope that they will remain dry, then specifications tests should be designed to provide data that show whether or not the cementing material has properties that are conducive to the attainment of a dry wall. Of course, they should also indicate the probable masonry strength obtainable with the cement in question. The test data, however, (1) should be indicative of masonry rather than of mortar strength and (2) should be obtained with curing conditions that at least roughly parallel the conditions that may be normally expected in a comparatively dry wall.

## II. Cementing Materials

In general, there are three main types of cementing materials used in mortar for unit masonry: lime, Portland cement, and masonry cement. There are strict limitations and requirements as to chemical compositions in the present standard federal and A.S.T.M. specifications for lime and Portland cement. The complete absence of any mention of chemical composition in specifications for masonry cement, however, is indicative of the wide variability of this class of material. The good performance of certain masonry cements in the tests for water-tightness indicates that there has been an intelligent effort on the part of producers to supply users with a good product. On the other hand, many technical buyers are skeptical about masonry cements both

on account of the inadequacy of present specifications and because they know something from experience concerning the variability of these products.

Most of the masonry cements consist of natural cement to which is added a plasticizing agent such as stearic acid, clay, calcium stearate, etc. It is incorrect in the light of present knowledge to call any of these additions "water-proofing" materials. To a limited extent they act as water repellents, but their chief function is to improve workability and water-retaining capacity. Such materials have no cementing value or bonding power and often interfere in getting good intensity of adhesion. Specifications forbid the use of a mortar sand containing an appreciable amount of clay and yet the masonry cement may contain it in liberal quantity.

In the use of mixtures of lime and Portland cement that meet specification requirements, it has been a custom to proportion these materials on a volume basis. Existing data indicate that the best combination of masonry strength and water-tightness is obtained with a mixture of approximately equal parts by weight of these two essential mortar ingredients. Since it is an established custom to proportion on a volume basis, then a mixture of two volumes of stiff lime putty to one volume of Portland cement may be taken as approximately equal parts by weight of the two materials. On this 2 to 1 volume basis, the actual weight of Portland cement slightly exceeds that of the lime putty minus the weight of the uncombined water which the putty contains. Nine volumes of sand added to the two of lime putty and one of Portland cement provide a mortar that is adaptable to a diversity of brick and suitable for all ordinary above-grade brickwork. For higher masonry strength, it is best to reduce the relative amount of sand, maintaining the same 2 to 1 volume proportion of lime to cement. For all brickwork below grade, 1 volume each of lime putty and Portland cement to 5 or 6 volumes of sand is the most suitable mixture.

Lime is the oldest mortar material and for thousands of years it has been slaked and used on the job as putty. Today both dry hydrated lime and slaked lime putty are used. It is believed that when hydrated lime is used best results are obtained by presoaking it for at least 24 hours, adding enough water to make a stiff putty.

With the use of properly proportioned mixtures of lime and Portland cement or with any other mortar mixtures having the same properties it is possible to use practically any type of well-fired brick that is sold on the present market and obtain water-tight masonry of good strength.

National Lime Association
927 Fifteenth Street, N. W.
Washington, D. C.

# THE INFLUENCE OF SODIUM ALUMINATE IN A FIRECLAY SEWER-PIPE BODY*

By W. K. Carter,† Geo. H. Duncombe,† E. E. Hillyer,‡ and R. M. King**

Abstract

A laboratory study of the effect of sodium aluminate on the fired properties of a fire clay used in sewer pipe is discussed, especially with respect to the original kiln strength and strength permanency. The results of commercial applications of sodium-aluminate additions in sewer-pipe plants are given.

## I. Introduction

Recent years have witnessed increasing appreciation of the fact that some present-day ceramic ware undergo considerable reduction in mechanical strength within a relatively short period of time after manufacture.

It is probable that practically all of the so-called heavy clay products are subject to this reduction in some degree even though the majority of products are not seriously affected, since notwithstanding it they possess an excess of strength above that required in service.

It is evident that volume, form, and composition of the surface, with respect to internal structure, may influence the effectiveness of reactions inherently related to material characteristics. These factors would lead to the expectation that the strength reduction, due to weather variations in storage or quiescent service, would be greater in the case of sewer pipe than most other heavy clay products and would be of considerable economic importance since this product must meet definite strength specifications which often are uncomfortably close to the normal production level.

Data obtained by one of the authors, in the course of investigation of sewer-pipe characteristics in plants in various parts of the country, have divulged the following information:

The earliest investigations of strength reduction of sewer pipe during weathering were comparisons of 12-, 15-, and 18-inch pipe taken from the kiln and after six months' storage. The percentage loss in six months varied in different plants from 5% to approximately 20%.

Subsequently, an extensive investigation at one plant operating with a widely used type of fire clay showed that, under the best firing conditions, kiln strength could be produced greatly in excess of normal levels but that even under most favorable conditions the loss from weathering was from 35 to 40% in ware 18 inches in diameter and larger, the greater part taking place in two months. The decrease was less with smaller pipe, being negligible from a commercial aspect in 10-inch diameter ware and smaller.

Additions of shale up to 60% did not alter the characteristic weathering appreciably and led to the conclusion that the problem could not be solved by admixtures of sizable percentages of other raw materials.

In the course of this work it was found that the rate of loss of strength was influenced by moisture availability and that pipe stored in the shop showed much less loss within the same period.

A test to accelerate the rate of loss was devised, which consisted of alternated cycles of steaming for 6 hours and drying for 18 hours under normal pressure. This treatment showed maximum loss developed at 6 cycles, with no further loss at 20 cycles. The strength losses produced were of the same magnitude as those taking place on the yard in 3 months.

Laboratory studies of variations involving weathered *vs.* unweathered clay and pure water *vs.* water containing soluble salts indicated that weathering of the clay increases the kiln strength appreciably and that pure water does not affect kiln strength but does reduce the weathering loss. In connection with the investigation of water-variation influence, it was found that while crystals consisting chiefly of $CaSO_4$ and $MgSO_4$ and NaCl could be leached from fired bodies tempered with both pure (steam condensate) and impure water, the rate of leaching and crystal development was much more

* Presented at the Annual Meeting, American Ceramic Society, Buffalo, N. Y., February, 1935 (Structural Clay Products Division).

† National Aluminate Corp., Chicago, Ill.
‡ Clay City Pipe Co., Urichsville, Ohio.
** Department of Ceramic Engineering, Ohio State Univ., Columbus, Ohio.

rapid from bodies tempered with impure water. No accurate quantitative measurements could be made, but the quantity of crystals developed was estimated to be greater from the impure water specimens.

Efforts to convert soluble salts in the water and clay by the addition of the usual antiscum treatment showed no improvement in kiln strength or weathering loss.

Laboratory studies on the effect of various flux additions, together with the tempering-water variations previously described, under various firing treatments showed complex alumina-bearing mineral fluxes exerting somewhat favorable influence, while the simple fluxes increased the weathering reduction.

None of the laboratory results showed a degree of improvement, which indicated a commercial solution of the "weathering" problem.

The only definitely established fact bearing on strength-reduction phenomena was that moisture is essential to the reaction. There is no evidence of porosity or soluble salt content variation having consistent relation as should be expected. Numerous theories have been advanced by those interested in the problem, but all encounter sufficient conflicting evidence to lead to the conclusion that true basic reactions have not been isolated.

The indicated value, however, of the complex alumina-bearing fluxes and pure water, coupled with knowledge of the known action of sodium aluminate in water treatments and as a fluxing and mineralizing agent in ceramic bodies, led to the opinion that it might be an inclusion which would alter matrix characteristics sufficiently to produce a commercially valuable decrease in the usual strength reduction.

The investigations with which this paper is concerned included an extensive laboratory study of the influence of sodium aluminate and two other chemicals on the physical properties of a typical Ohio coal-measure fire clay and a partially complete study of commercial results obtained when the most favorable laboratory treatment was translated to plant operation in three sewer-pipe plants using the same type of material but producing ware differing considerably in fired physical characteristics.

Since sodium aluminate was the only material which, in the laboratory investigation, showed favorable influence on strength "weathering" loss, this paper is limited to the consideration of its influence, and only sufficient reference to the voluminous laboratory data is included to show the trend of its effect and to indicate the similarity of laboratory and plant results.

Aside from several miscellaneous observations of interest, the report is concerned with strength data.

## II. Method of Procedure

### (1) Laboratory Test Procedure

The laboratory investigation consisted of a comparative study of the physical properties, in the dry state and after firing at various temperatures (cone fusion) from below the maturing temperature through early overfiring, of bodies containing chemical additions in increasing percentages up to 1%. In addition to the groups which were fired at the various temperatures in the laboratory, a complete series was fired in a commercial salt-glaze kiln. The entire study included over 10,000 specimens.

Customary laboratory methods of making determinations were employed. Chemical additions were made in solution in the tempering water. Bodies were made into 1-inch bars with a small auger machine and, to minimize the influence of mechanical variations, they were arranged so that consecutive bars from the machine appeared in order in each of the groups of specimens which were the basis of an average. Kiln and weathered comparisons in all cases were made between consecutive specimens from the auger machine fired side by side in the kiln. Strength was based on an average of 12 specimens broken on a 5-inch span in a Riehle cross-breaking machine.

The "weathering" treatment consisted of 12 cycles of steaming 6 hours and drying 18 hours.

### (2) Plant Test Procedure

The raw material used in the first plant (A) test was of the same general type and from the same district as the material with which the laboratory investigation was made.

Normal operating procedure for tempering, pressing, and drying was used.

Sodium aluminate additions were made in solution in all of the tempering water.

Sewer pipe were made, 18-inch to 2-foot double strength, all ware being marked serially

as it came from the press. There were about 60 pieces in each group of which 40 were designated as test specimens, the remainder being set aside on account of the overlap of material in process through the press.

Test specimens were set in groups of four adjacent stands from each test to obtain 10 specimen averages of each group for testing: (1) immediately after drawing from the kiln, (2) after weather-testing with steamer treatment, and (3) after normal yard storage conditions for a period of time.

The firing treatment of the test ware was

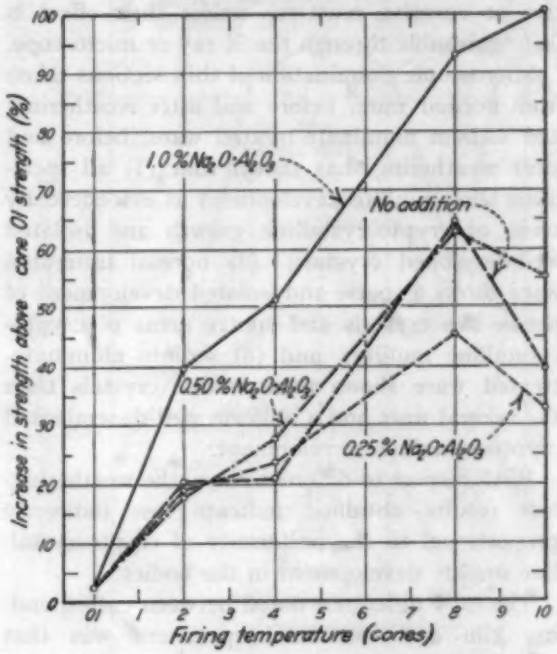

Increase in strength above cone 01 strength (%)
Firing temperature (cones)
1.0 % $Na_2O \cdot Al_2O_3$
No addition
0.50 % $Na_2O \cdot Al_2O_3$
0.25 % $Na_2O \cdot Al_2O_3$

FIG. 1.—Laboratory study showing the influence of sodium aluminate additions to a fire clay upon the characteristic strength curve developed in the firing range from cones 01 to 10.

altered somewhat from normal plant practice principally in that care was exercised to insure thorough oxidation, and a somewhat slower vitrification rate was employed. Normal plant practice was followed in cooling.

The ware was drawn as soon as the kiln was cool enough to work comfortably and, within the next twenty-four hours, the specimens from which kiln-strength averages were obtained were broken and a second portion of each test group was subjected to intensive "weathering" treatment, as previously described. Pipe were set so that kiln and weathered comparisons could be made between the consecutive pipe from the press fired in adjacent kiln locations.

The test specimens were broken on a Riehle crushing machine, using the A.S.T.M. three-point bearing method and load application rate.

Plant tests B and C involved the same general type of material, and the same test procedure was employed.

In reporting the results of commercial applications, actual strength levels are given for plant A; gross averages of all specimens tested are reported, these averages being the mean of 8 to 12 specimens in each instance.

The data on plants B and C take the form of percentage increase or decrease compared to untreated ware from the test kiln, since it is not

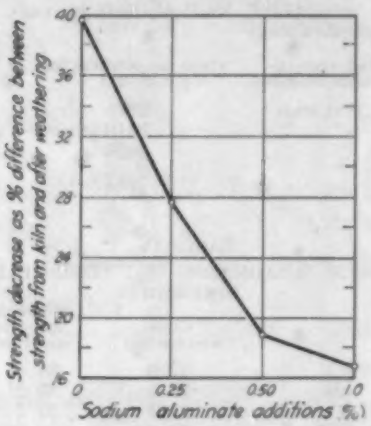



FIG. 2.—Laboratory study showing influence of sodium aluminate additions upon the strength permanency of laboratory specimens salt-glazed in a commercial kiln fired at cone 8.

desirable to inject comparisons between strength levels of competitive plants.

## III. Data

### (1) Laboratory Results

Excerpts from the laboratory results are shown in Tables I and II. These data are shown graphically in Figs. 1 and 2.

TABLE I

STRENGTH INCREASE OVER CONE 01 (LABORATORY FIRED)

| Cone | No addition (%) | Sodium aluminate additions 0.25% (%) | 0.50% (%) | 1.00% (%) |
|---|---|---|---|---|
| 2 | 20.9 | 17.1 | 15.2 | 39.4 |
| 4 | 22.4 | 24.5 | 28.2 | 52.0 |
| 8 | 64.8 | 48.0 | 63.9 | 91.3 |
| 10 | 39.8 | 33.9 | 55.2 | 101.2 |

TABLE II

LOSS FROM WEATHERING (COMMERCIAL, GLAZED, CONE 8)

| | (%) |
|---|---|
| No addition | 39.6 |
| 0.25 % sodium aluminate | 27.7 |
| 0.50 % " " | 19.1 |
| 1.0 % " " | 17.2 |

## (2) Plant Results

TABLE III

| | Kiln strength (18-in. double strength) | Gross average crushing load (ft.-lb.) |
|---|---|---|
| (*a*) | Regular ware (plant records) | 3400 |
| (*b*) | Regular ware (25-in. vacuum de-airing) | 3700 |
| (*c*) | Test ware (0.10% tribarium aluminate) | 4560 |
| (*d*) | Test ware (16-in. vacuum de-airing–0.10% tribarium aluminate) | 4675 |
| (*e*) | Test ware (0.10% tribarium aluminate–0.25% $Na_2O \cdot Al_2O_3$) | 4580 |
| (*f*)* | Test ware (0.50% $Na_2O \cdot Al_2O_3$) | 3955 |
| (*g*) | Test ware (1.0% $Na_2O \cdot Al_2O_3$–16-in. vacuum de-airing) | 5025 |

| Weathered strength (18-in. double strength) | | Gross av. crushing load (ft.-lb.) | % A.S.T.M. |
|---|---|---|---|
| (*c*) | Test ware | 2875 | 186 |
| (*d*) | " " | 3410 | 220 |
| (*e*) | " " | 3425 | 222 |
| (*f*)* | " " | 2995 | 192 |
| (*g*) | " " | 4175 | 271 |

TABLE IV

LOSS FROM WEATHERING (%) (18-INCH DOUBLE STRENGTH)

| | Gross average loss | Minimum adjacent stand loss |
|---|---|---|
| (*c*) | 37.9 | 34.4 |
| (*d*) | 27.1 | 28.2 |
| (*e*) | 27.4 | 27.7 |
| (*f*)* | 24.2 | 8.0 |
| (*g*) | 15.9 | 7.0 |

* Uniformity of effect was displayed with both high and low percentage chemical addition. The intervening test series with intermediate percentage chemical addition did not conform with respect to strength from the kiln but did conform as to loss from weathering. This series contained a number of specimens with structural defects which obviously lowered the kiln strength and obscured the material expectancy.

Partial data from Plants B and C are shown in Table V and presented in Fig. 7 (investigation not completed).

TABLE V

| Plant B (%) | Increase in kiln strength (%) | Decrease from weathering (%) |
|---|---|---|
| No addition | 0.0 | 20.0 |
| 0.25 $Na_2Al_2O_4$ | 0.0 | 16.7 |
| 0.50 $Na_2Al_2O_4$ | 4.0 | 8.0 |
| 1.0 $Na_2Al_2O_4$ | 16.0 | 0.0 |
| **Plant C (%)** | | |
| No addition | 0.0 | |
| 0.25 $Na_2Al_2O_4$ | 4.0 | |
| 0.50 $Na_2Al_2O_4$ | 26.0 | |
| 1.0 $Na_2Al_2O_4$ | 29.0 | |

## IV. Petrographic Analysis

When it is considered that strength loss during weathering can conceivably result from the individual or combined effect of reactions, such as clay rehydration, hydration of uncombined impurities, differential expansion in the ware, or between the body and water-vapor, lack of sufficient annealing opportunity, or chemical and mechanical disintegration of the bonding matrix due to solution, strain, crystallization, or incompatibility of bond and body, it becomes apparent that, except by synthesis, it may be impossible to isolate the definite effect of destructive or curative reactions unless their effect is distinguishable through the X-ray or microscope.

Microscopic examination of thin sections taken from normal ware, before and after weathering, and sodium aluminate-treated ware, before and after weathering, has shown that (1) all specimens show mullite development as evidenced by areas of cryptocrystalline growth and isolated well-developed crystals; (2) normal untreated ware shows a sparse and isolated development of needle-like crystals and spotty areas of cryptocrystalline mullite; and (3) sodium aluminate-treated ware shows more needle crystals than the normal ware and a uniform well-disseminated cryptocrystalline development.

With respect to different clays, the weathering-loss results obtained indicate loss indirectly proportional to the uniformity of cryptocrystalline mullite development in the bodies.

The only difference noted between corresponding kiln and weathered specimens was that normal weathered ware showed an occurrence of shattered glass and quartz areas not found in any of the kiln specimens. There was no distinction between kiln and weathered specimens of sodium aluminate-treated ware.

Since the shattering may have been incident to specimen preparation, no definite significance can be attached to this observation unless sufficient additional determinations confirm its uniform occurrence.

Figure 8 shows crystal development after reheating in bodies from plants A and B.

Figure 8 (upper left) is from normal ware from plant A and the upper right photomicrograph is from ware containing 1.0% sodium aluminate.

The lower left photomicrograph in Fig. 8 is from normal ware from plant B and the lower

right is from ware containing 1% sodium aluminate.

The effect of the aluminate addition is clearly evidenced by both comparisons. The distinction between the normal ware from the two plants is also quite evident and significant in view of the differences in normal weathering-strength loss shown by the weathering tests. That is, there is evidence, by the comparison of untreated ware from plants A and B, that normal

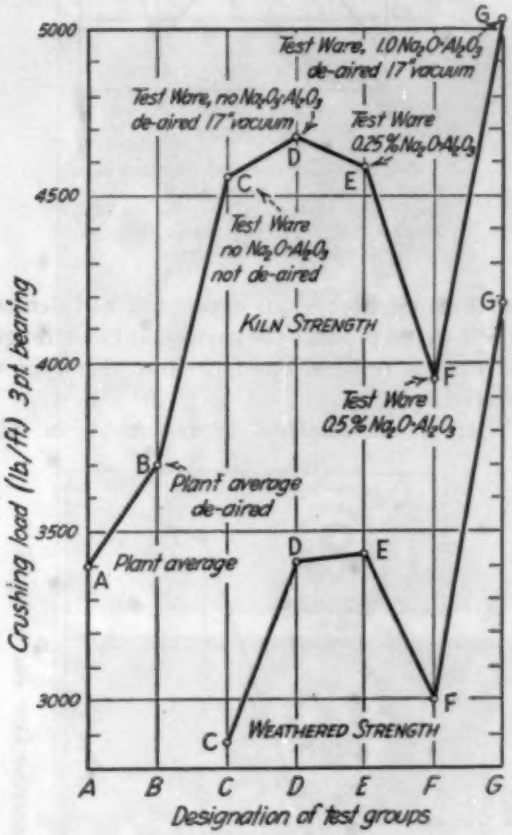



Fig. 3.—Gross kiln and weathered strength (plant A).

weathering-strength deterioration is related to the mullite development in indirect order.

Both of the treated specimens show enhancement of the mullite development with accompanying decrease in weathering-strength loss.

The entire petrographic analysis has involved too few determinations to permit offering it as more than a hint that strength loss may be involved with crystal structure. It certainly may be considered of possible significance, in view of the fact that sodium aluminate, a material having proved unusual mineralizing action in other usages, produces the results which have been reported.

Further study is being carried on in connection with weathering tests in the attempt to isolate definitely any influence of mineral characteristics on strength reduction.

## V. Discussion

### (1) Miscellaneous Observations (Plant and Laboratory)

A commercially negligible porosity increase is in evidence with higher concentrations of sodium aluminate.

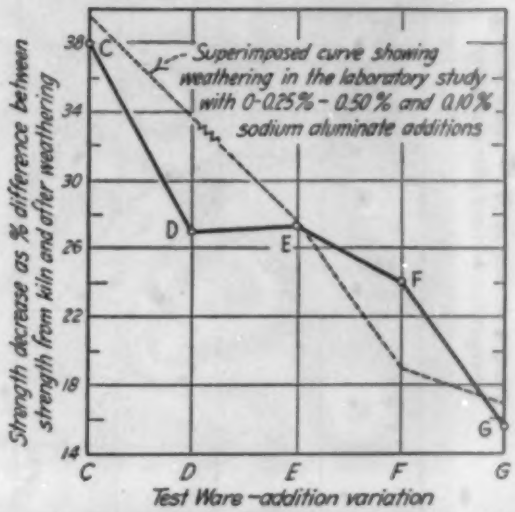



Fig. 4.—Commercial application, plant A, showing strength decrease from weathering; gross averages. Test ware *C*, 0% $Na_2O$·$Al_2O_3$; *D*, 0% $Na_2O$·$Al_2O_3$ (de-aired 17-in. vacuum); *E*, 0.25% $Na_2O$·$Al_2O_3$; *F*, 0.50% $Na_2O$·$Al_2O_3$; *G*, 1.0% $Na_2O$·$Al_2O_3$ (de-aired 17-in. vacuum).

In the laboratory it was found that characteristic shrinkage was produced earlier in the firing range and existed with less change over the normal and into the overfiring range.

Oxidation processes in all the material tested proceed with much greater facility in bodies containing the higher concentrations of sodium aluminate.

Considerable antiscum reaction is noted from the use of small concentrations in salt-glazed ware, and customarily desired color development is appreciably facilitated.

### (2) Laboratory Study

Figure 1 shows graphically (1) the influence of higher concentrations of sodium aluminate

in increasing the characteristic strength development of the material throughout the firing range; (2) the influence of sodium aluminate to produce strength increase in the firing range between cones 2 and 4 where normally no increase is produced; and (3) the influence of sodium aluminate in producing further increase of kiln strength in the temperature range where normally the kiln strength decreases rapidly from overfiring.

Figure 2 shows graphically the influence of sodium aluminate in reducing the loss from

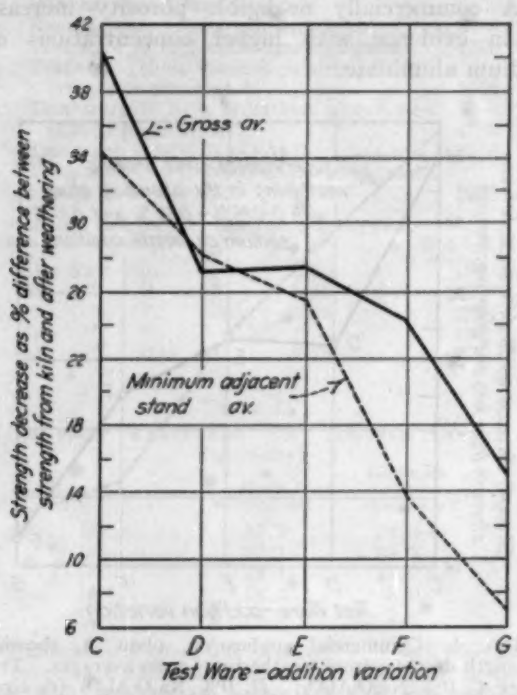



FIG. 5.—Commercial application, plant A, showing comparison of gross average decrease with minimum decrease obtained between any adjacent stands. *C*, no $Na_2O{\cdot}Al_2O_3$; *D*, no $Na_2O{\cdot}Al_2O_3$ (de-aired, 17-in. vacuum); *E*, 0.25% $Na_2O{\cdot}Al_2O_3$; *F*, 0.50% $Na_2O{\cdot}Al_2O_3$; *G*, 1.0% $Na_2O{\cdot}Al_2O_3$ (de-aired, 17-in. vacuum).

weathering of commercially fired salt-glazed specimens; these changes indicate that sodium aluminate additions exert considerable influence on the firing behavior and resultant physical characteristics.

### (3) Plant Results

In considering the plant results, it should be kept in mind that no data are included to show the weathered strength level of untreated or de-aired ware under normal firing conditions. The object of the work was to determine what, if any, improvement over and above the maximum quality obtainable from the material itself would result from the use of sodium aluminate. With that in view, the firing treatment employed

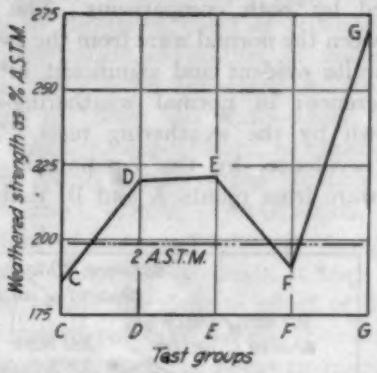



FIG. 6.—Commercial application, plant A. *C*, no $Na_2O{\cdot}Al_2O_3$; *D*, no $Na_2O{\cdot}Al_2O$ (de-aired); *E*, 0.25% $Na_2O{\cdot}Al_2O_3$; *F*, 0.50% $Na_2O{\cdot}Al_2O_3$; *G*, 1.0% $Na_2O{\cdot}Al_2O_3$ (de-aired).

was that which previous experience had demonstrated would produce the maximum kiln strength and highest residual strength from this type of material.

That a considerable improvement in kiln

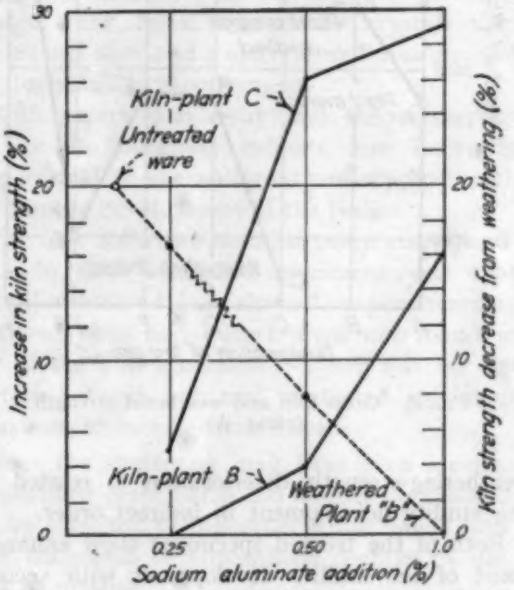



FIG. 7.—Commercial applications, plants B and C; kiln and weathered strength.

strength was due to the firing treatment is evident from the comparative levels of A and B *versus* C and D (Fig. 3).

Having in mind that group F contained many defective specimens which obviously lowered

the strength level, the significance of its level as shown in Fig. 3 is somewhat doubtful, particularly in view of the fact that the strength levels of this series in plants B and C (Fig. 7) conform to expectation.

It is of interest to note that the influence of sodium aluminate in reducing the loss from "weathering" as obtained in the laboratory investigation agrees, in general, with the results obtained in plants A and B (Figs. 4 to 7).

The probability that the gross averages shown do not represent the maximum material expectancy is evidenced by the comparison of gross averages with m.nimum adjacent stand averages (Fig. 5).

The test at plant A indicates the possibility of making ware with residual strength well above normal kiln strength (Fig. 3), and it does not seem unreasonable to anticipate a level well above twice the A.S.T.M. requirements (Fig. 6).

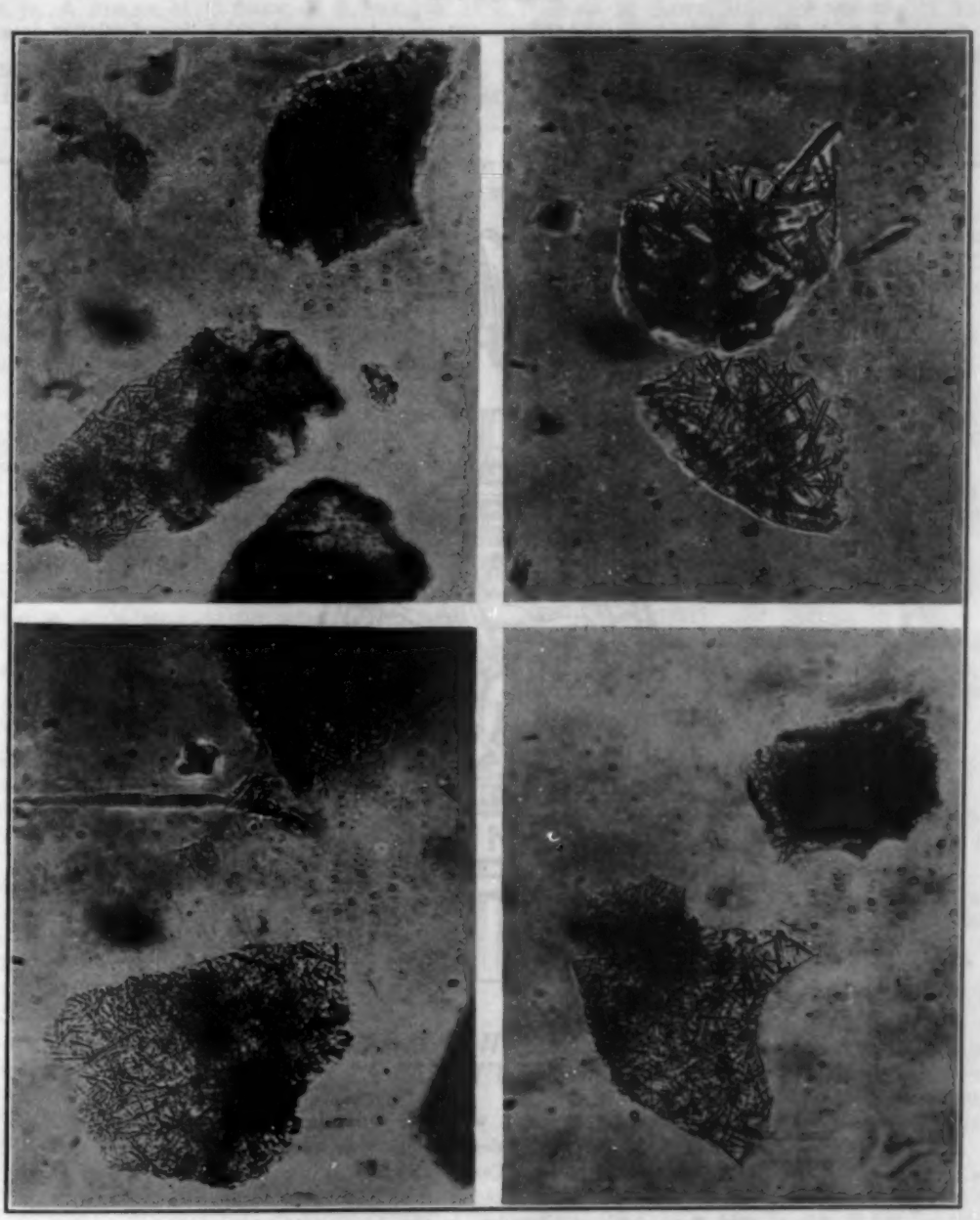


FIG. 8.—*Upper left*, plant A, no addition; *upper right*, plant A, 1% sodium aluminate; *lower left*, plant B, no addition; *lower right*, plant B, 1% sodium aluminate.

## VI. Conclusions

Sodium aluminate additions increase kiln strength and reduce the loss of strength from weathering. These effects are associated with a definite alteration of the normal mineral structure.

National Aluminate Corporation
6216 West 66th Place
Chicago, Illinois

---

## ERRATUM

R. E. Birch and F. A. Harvey, "Forsterite and Other Magnesium Silicates as Refractories," June *Journal*, page 191, second paragraph, third line of tabular data should read as follows:
Ignition loss (0.58% accounted for in *chlorite*) 0.95, etc.

---

## WHY NOT WEAR YOUR SOCIETY KEY?

Keys can be supplied with the appropriate title for Members, Fellows, Student Members, or Corporation Members of the American Ceramic Society.

The cost is $3.25 for a gold-filled and $6.50 for a solid gold key. Address all orders to the American Ceramic Society, 2525 N. High St., Columbus, Ohio.

# CERAMIC ABSTRACTS[1]

Compiled by the

AMERICAN CERAMIC SOCIETY

Ross C. Purdy, Editor

Abstracters: A. Ally, J. B. Austin, A. A. Ayars, R. Barta, M. H. Berns, L. T. Brownmiller, P. Budnikoff and E. Stepanowsky, W. M. Cohn, M. V. Condoide, J. L. Gallup, Max Hartenheim, F. G. Heck, R. A. Heindl, E. B. Hewitt, G. M. Hutt, A. Kuechler, J. T. Littleton, S. I. Perkal, J. G. Phillips, R. H. H. Pierce, Jr., A. Pincus, M. C. Shaw, G. R. Shelton, H. E. Simpson, H. Smith, H. H. Stephenson, H. Türk, E. J. Vachuska, H. F. Vieweg.

**Vol. 14** **August, 1935** **No. 8**

## Abrasives

**Acid-resistant putties and concretes.** B. G. Perets and E. N. Tretyakova. *Trans. Sixth Mendeleiev Congress*, 2 [1] 291–313 (1935).—An experiment has been made to prepare and study putties and concretes for apparatus used in sulfuric acid manufacture. The putties have been made by mixing different natural or artificial materials rich in silica with sodium silicate. If accelerators are used, *e.g.*, $Na_2SiF_6$, a reaction takes place as follows: $Na_2SiF_6 + 4NaOH = 6NaF + SiO_2 + 2H_2O$. Without accelerators, which hasten the setting and hardening, the silicate masses harden too slowly, taking from one to several months. Substances reacting with sodium silicate may serve as accelerators. They combine the alkali of the soluble glass or interact with silicic acid. To the first group of substances belong ammonium chloride, sodium silico-fluoride, acids, etc.; to the second group belong basic compounds, such as calcium oxide, magnesium oxide, carbonates, and other salts of alkali-earth metals.

S.I.P.

### PATENTS

**Abrading machine.** Charles Johnson (Mattison Machine Works). U. S. 2,002,665, May 28, 1935 (Aug. 15, 1930).

**Abrading or polishing machine.** Charles Johnson and C. L. Mattison (Mattison Machine Works). U. S. 2,002,666, May 28, 1935 (June 29, 1932).

**Abrasive.** J. B. Dietz and H. L. Plummer (E. I. du Pont de Nemours & Co.). U. S. 2,004,466, June 11, 1935 (April 28, 1931).

**Abrasive articles.** W. J. Tennant (Durex Corp.). Brit. 427,978, May 15, 1935 (Nov. 3, 1933).

**Abrasive hand-dressing tools.** C. Crawley. Brit. 428,630, May 29, 1935 (Dec. 7, 1933).

**Annealing or other heat-treating chambers.** J. P. D. Coleman and Wild-Barfield Electric Furnaces, Ltd. Brit. 427,964, May 15, 1935 (Oct. 28, 1933).

**Apparatus for determining toughness or resistance to breakage of abrasive bodies by impact.** R. L. Melton and John Fitzpatrick (Carborundum Co.). U. S. 2,003,863, June 4, 1935 (Oct. 9, 1929).

**Apparatus for manufacture of molded articles such as tile.** E. O'Sullivan. Brit. 427,783, May 15, 1935 (Oct. 30, 1934).

**Automatic grinding machine.** Harry Arter and W. F. Fraser (Arter Grinding Machine Co.). U. S. 2,003,269, May 28, 1935 (March 25, 1933).

**Buffing or polishing wheel.** A. S. Yohe (Bias Buff & Wheel Co., Inc.). U. S. 2,004,623, June 11, 1935 (Feb. 1, 1934).

**Caliper controlled grinding machine.** A. G. Belden and R. A. Cole (Norton Co.). U. S. 2,003,334, June 4, 1935 (July 25, 1931).

**Device for spherical grinding on circular grinding machines.** Julius Grundstein (Ges. des ächten Naxos-Schmirgels Naxos-Union Schmirgel-Dampfwerk Frankfurt a.m. Julius Pfungst). U. S. 2,003,883, June 4, 1935 (Jan. 20, 1934).

**Fixture for turning or grinding ovals.** A. J. Hurt. U. S. 2,004,283, June 11, 1935 (Feb. 27, 1934).

**Form grinding.** Coventry Gauge & Tool Co., Ltd., and S. J. Harley. Brit. 427,811, May 15, 1935 (Nov. 1, 1933).

**Grinding apparatus.** B. O. Isom (Hutto Engineering Co., Inc.). U. S. 2,004,949, June 18, 1935 (July 23, 1928). R. E. Spurr (Chrysler Corp.). U. S. 2,002,967, May 28, 1935 (July 3, 1933).

**Grinding disk.** Carl Krug. U. S. 2,004,630, June 11, 1935 (March 30, 1934).—A grinding wheel of uniform basic structure has an arbor hole through it and an outer zone and a relatively narrow inner annular zone adjacent the arbor hole to which has been added a strengthening material throughout the thickness of the wheel. The outer zone is unchanged.

**Grinding machine.** Clement Booth (Cincinnati Grinders, Inc.), U. S. 2,004,427, June 11, 1935 (July 3, 1931). Clement Booth and F. S. Haas (Cincinnati Grinders, Inc.), U. S. 2,004,426, June 11, 1935 (March 28,

[1] The bold-face number following the journal is the volume, the issue number is in brackets, followed by the page numbers, then the year in parentheses.

Abstracts from our abstracter in Czechoslovakia are sent to us through the Czechoslovak Ceramic Society, Praha XIX, 1417.

1930). CLEMENT BOOTH AND ANDREW STROM (Cincinnati Grinders, Inc.), U. S. 2,002,489, May 28, 1935 (July 3, 1931). C. J. HIGHBERG (Heald Machine Co.), U. S. 2,003,713, June 4, 1935 (March 31, 1928). EMIL RITZ, JR. (Hisey-Wolf Machine Co.), U. S. 2,003,495, June 4, 1935 (April 11, 1930).

**Grinding machine guide block.** JOSEPH SUNNEN. U. S. 2,002,649, May 28, 1935 (May 7, 1934).

**Grinding machinery.** L. F. NENNINGER (Cincinnati Grinders, Inc.). U. S. 2,002,921, May 28, 1935 (May 3, 1933).

**Grinding machines for crank shafts.** M. SEEST JERNST Ö BERI OG MASKINFABRIK AKTIESELSKAB. Brit. 428,707, May 29, 1935 (Nov 21, 1932).

**Honing tool.** K. W. CONNOR (Micromatic Hone Corp.). U. S. 2,002,567, May 28, 1935 (Jan. 8, 1934).

**Internal grinding machine.** H. H. ASBRIDGE (Churchill Machine Tool Co., Ltd.). U. S. 2,005,331, June 18, 1935 (July 3, 1934), and U. S. 2,005,332, June 18, 1935 (Dec. 14, 1934).

**Manufacture of abrasive articles.** A. L. BALL AND R. C. BENNER (Carborundum Co.). U. S. 1,998,919, April 23, 1935 (Nov. 12, 1931).—An artificial abrasive wheel is adapted for peripheral grinding wherein the power is transmitted from opposed driving flanges which press axially against the wheel and wherein an annular member is disposed between one of the flanges and the wheel, the annular member having a coefficient of expansion which compensates in an axial direction for the difference between the respective thermal expansions of the wheel and of the supporting means.

**Method and apparatus for grinding valve seats.** VAN NORMAN MACHINE TOOL CO. Brit. 428,427, May 22, 1935 (Feb. 10, 1934).

**Method and apparatus for manufacturing articles of bonded granules.** R. C. BENNER, P. H. WALKER, AND W. G. SOLEY (Carborundum Co.). U. S. 2,003,131, May 28, 1935 (Feb. 13, 1933; Dec. 14, 1933).

**Method of grinding work pieces.** CLEMENT BOOTH AND SOL EINSTEIN (Heald Machine Co.). U. S. 2,004,649, June 11, 1935 (May 19, 1930).

## Art and Archeology

**American glass.** JOSEPH DOWNS. *Bull. Met. Mus. Art*, **30** [2] 33–35 (1935).—Several examples of American glass from the 18th and early 19th Centuries include a toilet water bottle of Stiegel glass, a set of two white flip glasses, a large tumbler of aquamarine color which may have been made by Craig and O'Hara of Pittsburgh, a large sweetmeat jar of pale green glass, and a three-mold glass bowl. A.A.A.

**Animals in porcelain.** H. BELLAMY GARDNER. *Trans. English Ceram. Circle*, No. 2, pp. 17–21 (1934).—Drawings of animals and figures modeled in the round in china are discussed. Illustrated. H.S.

**Authorship of designs on porcelain and enamel and Robert Hancock's connection with Battersea and Bow.** H. W. HUGHES. *Trans. English Ceram. Circle*, No. 3, pp. 85–96 (1935).—Illustrated. H.S.

**Battersea factory.** BERNARD RACKHAM. *Trans. English Porcelain Circle*, No. 4, pp. 69–74 (1932).—R. supplements his earlier paper (see "Porcelain—," this issue). Illustrated. H.S.

**Bristol biscuit plaques.** WALLACE ELLIOT. *Trans. English Ceram. Circle*, No. 1, pp. 23–29 (1933).—Plaques made at Richard Champion's factory at Bristol possess intricate detail. Illustrated. H.S.

**Bristol delftware.** GILBERT MELLOR. *Trans. English Ceram. Circle*, No. 2, pp. 22–28 (1934).—Delftware, meaning here tin-enameled earthenware, made at Bristol is discussed. This ware was first made at Bristol in the middle of the 17th Century and was continued until the end of the 18th Century when Staffordshire and similar products usurped its market. Illustrated. H.S.

**Chelsea chronology.** WILLIAM KING. Abstracted in *Trans. English Ceram. Circle*, No. 1, pp. 9–11 (1933).—K. discusses discoveries concerning Chelsea porcelain since the publication of his book on this subject in 1922. H.S.

**Chelsea figure of Aesop.** H. BELLAMY GARDNER *et al.* *Trans. English Porcelain Circle*, No. 4, pp. 17–19 (1932).—Illustrated. H.S.

**Chelsea, the triangle period.** O. GLENDENNING AND MRS. DONALD MACALISTER. *Trans. English Ceram. Circle*, No. 3, pp. 20–36 (1935).—The 18th Century china factory of Nicholas Sprimont at Chelsea and pieces belonging to all known types of the triangle period are discussed. Illustrated. H.S.

**Chinese Lowestoft toddy jug.** JOSEPH DOWNS. *Bull. Met. Mus Art*, **30** [2] 38–40 (1935).—A recently acquired example of Chinese Lowestoft porcelain, decorated upon the order of a Philadelphia merchant, is unusual in history and design. A portrait of Washington is painted on one side, and the monogram, ET, on the reverse side is that of Edward Tilghman, born in Wye, Md., and a prominent member of the Bar in Pennsylvania. A.A.A.

**Cross-currents in English porcelain, glass, and enamels.** HERBERT READ. *Trans. English Porcelain Circle*, No. 4, pp. 7–17 (1932).—R. states that collectors should study decoration independent of the study of material, and that collectors are on safe ground when the researches into decoration and into material meet at the same point. Illustrated. H.S.

**Derby painters, John and Robert Brewer.** W. H. TAPP. *Trans. English Porcelain Circle*, No. 4, pp. 75–90 (1932).—The work of the Brewer brothers is discussed in detail. Illustrated. H.S.

**Derby pattern books. Billingsly figure and landscape subjects.** W. H. TAPP. *Trans. English Porcelain Circle*, No. 3, pp. 85–91 (1931).—T. discusses specimen pages of the Derby pattern books and examples of the work of the enamelers. Illustrated. H.S.

**Early Staffordshire china.** MRS. DONALD MACALISTER. *Trans. English Ceram. Circle*, No. 1, pp. 44–53 (1933).—Porcelain was made in Staffordshire potteries in the middle of the 18th Century. It never rivaled salt glaze, however, and the deluge of creamware which flooded England after

Wedgwood perfected it in 1763 usurped its market. Illustrated. H.S.

**Electric muffles for firing (decorated) glass.** E. F. Russ. *Glas & App.*, **14**, 105–106 (1933); *Jour. Soc. Glass Tech.*, **18A**, 201 (1934).—Diagrams are given of muffle furnaces designed by R. Such muffles with a working volume of 610 mm. broad, 1050 mm. deep, and 850 mm. high, need 15 kw. and for a complete firing consume about 45 kw.-hr. which at 3 R. pfg. per kw.-hr. cost 1.35 Rm. The advantages of electric heating are stressed.

**Elers ware.** W. B. Honey. *Trans. English Ceram. Circle*, No. 2, pp. 7–16 (1934).—John Philip Elers and David Elers, Dutchmen who made red ware in Staffordshire late in the 17th Century, are credited with starting the rise of Staffordshire pottery from the level of butterpots and slipware to that of an art capable of refinement. Illustrated. H.S.

**English salt glaze. Helen and Carleton Macy Collection.** C. Louise Avery. *Bull. Met. Mus. Art*, **30** [3] 53–59 (1935).—The Macy collection of 18th Century English salt-glazed stoneware has been given to the Museum. There are 198 pieces of various types made from 1730 to 1770, chiefly in Staffordshire. Many correspond closely to pieces in the collection presented by Charles and Charlotte Schreiber to the Victoria and Albert Museum in 1884. Included in the collection are forty figures or groups, rare in comparison with tableware of the same period, besides bowls, bottles, teapots, etc. Some of these pieces commemorate historical events. A.A.A.

**English salt-glazed stoneware.** W. B. Honey. *Trans. English Ceram. Circle*, No. 1, pp. 12–22 (1933).—Beginning with John Dwight's first patent of 1671 covering the "misterie and invencon of making transparent earthen ware vulgarly called Collogne ware. . . not hitherto wrought or made in England," the work of the Fulham and Staffordshire periods is discussed. Illustrated. H.S.

**Excavations in North Staffordshire.** H. W. Maxwell. Abstracted in *Trans. English Ceram. Circle*, No. 1, pp. 57–58 (1933).—Fragments from the site of Thomas Whieldon's factory at Fenton Low, the site of the Elers pottery at Bradwell Wood, and another site in the center of Burslem in the Stoke-on-Trent district are shown. Illustrated. H.S.

**History of porcelain-making in London.** Aubrey J. Toppin. *Trans. English Ceram. Circle*, No. 1, pp. 30–43 (1933).—The history of the Kentish Town china factory is given. Illustrated. H.S.

**Inca mountain citadel of Pisaj.** Luis Valcarcel. *Illus. London News*, **186**, 594–95 (April, 1935).—Six photographs of new Peruvian discoveries are shown. H.H.S.

**Invisible writing on English porcelain.** Frank Hurlbutt. *Trans. English Ceram. Circle*, No. 1, pp. 54–56 (1933).—To record initials or figures old English porcelain painters sometimes employed invisible writing. The decorator took some of the soft glaze which is mixed with the metallic pigments in preparing colored enamels and used it alone as the medium for writing. When the article was fired the writing melted to a colorless transparent glaze adhering to the glazed body. When the surface is held obliquely to the light the writing can be detected by the slight iridescence which accompanies it. Other possible causes of such marks are also given. H.S.

**Janssen and the artists at the Battersea factory.** Aubrey J. Toppin. *Trans. English Porcelain Circle*, No. 4, pp. 58–68 (1932).—Information is given concerning John Brooks, who invented the process of printing on enamels which eventually became of great importance to the ceramic industry in England; James Gwim, a designer and engraver who worked at the Battersea factory managed by Brooks; John Hall, who was apprenticed to Janssen in the above-mentioned factory; Simon François Ravenet; William Wynne Ryland, who introduced the chalk or "dotted" manner of engraving; Robert Hancock; and Stephen Theodore Janssen, who financed the factory at Battersea over which Brooks had charge. Illustrated. H.S.

**Jason and the Golden Fleece.** G. M. A. Richter. *Bull. Met. Mus. Art*, **30** [4] 86–88 (1935).—An Athenian column krater just acquired by the Museum represents the legend of Jason and the Golden Fleece. The krater may be attributed to the Orchard Painter, called after the representation of an orchard on a vase in this Museum. The date of the vase is about 470 to 460 B.C. A.A.A.

**Lambeth delft.** Geoffrey Eliot Howard. *Trans. English Ceram. Circle*, No. 3, pp. 7–10 (1935).—Lambeth wine bottles of the 17th Century are discussed. Many are globular in shape with a narrow neck and a number have a white tin enamel glaze. Illustrated. H.S.

**Lithography decorations on pottery.** G. A. Wade. *Pottery Gaz.*, **60** [696] 766–68 (1935).—Ceramic printers see lithography for future pottery decoration but urge the need for greater collaboration with them on the part of pottery manufacturers, designers, and salesmen. The general public is afforded no opportunity of seeing the best modern lithographic work. E.J.V.

**Maltese pottery.** Anon. *Sydney Morning Herald*, May 4, 1935.—The government of Malta has presented to the Commonwealth Government of Australia a valuable collection of Maltese pottery dating from the 10th Century B.C. to the 3rd Century A.D. H.H.S.

**Memorial exhibition of work of Charles F. Binns.** C. Louise Avery. *Bull. Met. Mus. Art*, **30** [5] 106–108 (1935).—In appreciation of the achievements of Charles F. Binns as a potter and a teacher, the Metropolitan Museum arranged a memorial exhibition of his pottery. The exhibition is distinguished for the finished workmanship and the fine glazes. The pieces were made on the wheel and are simple and strong. For biography of C. F. Binns see *Bull. Amer. Ceram. Soc.*, **14** [1] 24 (1935). A.A.A.

**Miscellany of pieces.** Wallace Elliot *et al.* *Trans. English Ceram. Circle*, No. 3, pp. 12–19 (1935).—English ceramic pieces of special interest or doubtful origin are discussed. Illustrated. H.S.

**Modrá, the center of Slovakian ceramics.** R. Barta. *Zprávy Československ. keram. společnosti*, **10**, 8 (1933).—The descendants of the Anabaptists in Slovakia continue the national ceramic tradition started by their ancestors during the Middle Ages. This pottery is still produced in small workshops, but only in Modrá is there any large establishment producing this kind of work. In English, "Modrá" means blue, and blue is the typical color of ware produced there. Both ancient and modern work is made there.

Modrá has a small museum and a school for ceramic painters and potters. Directions for further activity in this ceramic center are proposed. R.B.

**Murano museum and glass.** ANON. *Céram., Verrerie, Émail.*, 2 [12] 521–22 (1934).—The museum of Murano, established in 1861 by Abbé Lanette, contains interesting collections of Italian and other glass. Its glasses, particularly the acid- and heat-resistant, are well known and some batch formulas are given. M.H.B.

**Polychrome transfer on porcelain.** NEWMAN NEILD. *Trans. English Ceram. Circle*, No. 3, pp. 71–72 (1935).—Early pieces which were transfer-printed and then painted in enamels, some of the enamels being the same colors as those of the print, are discussed. Illustrated. H.S.

**Porcelain decoration.** ARTHUR HURST. Abstracted in *Trans. English Porcelain Circle*, No. 4, pp. 20–21 (1932).—Types of decoration are briefly discussed. H.S.

**Porcelain as a sidelight on Battersea enamels.** BERNARD RACKHAM. *Trans. English Porcelain Circle*, No. 4, pp. 45–58 (1932).—Means of recognizing Battersea enamels are given. H.S.

**Recent excavation at Petra.** W. F. ALBRIGHT. *Discovery*, **16**, 68–71 (March, 1935).—The Melchett Fund Expedition is collecting important information concerning pre-Islamic Arabian civilization. Illustrated. H.H.S.

**Red art glazes.** J. LIEBSCHER. *Zprávy Československ. keram. společnosti*, **10**, 49 (1933).—The production of glazes using uranium and chromium is discussed. Successful formulas are given. R.B.

**Robert Hancock and his sons.** AUBREY J. TOPPIN. *Trans. English Ceram. Circle*, No. 2, pp. 42–43 (1934).—Additional information on these Battersea artists is given. Illustrated. H.S.

**Seasons' finds.** JOSEPH M. UPTON. *Bull. Met. Mus. Art* [Section II], **29** [12] 14–22 (1934).—Pottery and other clay objects found during the Persian Expedition of 1933–34 are described. Very few pieces were found intact. Several photographs of glazed and unglazed ware, with incised or combed decoration, are given. Some of the ware was polished instead of being glazed. A.A.A.

**Sloane's plants on Chelsea porcelain.** H. BELLAMY GARDNER. *Trans. English Porcelain Circle*, No. 4, pp. 22–25 (1932).—A Chelsea plate has decorations copied in every detail, including the dissections of the plant, from an engraving in a book (compiled by Philip Miller with the assistance of Hans Sloane) showing examples in the Physic Garden at Chelsea about 1755. Illustrated. H.S.

**Staffordshire slipware.** BERNARD RACKHAM. *Trans. English Ceram. Circle*, No. 3, pp. 57–70 (1935).—Ware designed for use or decoration in farmhouses, country taverns, etc., of the 17th Century is discussed. Illustrated. H.S.

**Sung pottery from the Shepard K. DeForest Collection.** PAULINE SIMMONS. *Bull. Met. Mus. Art* [Section I], **29** [12] 206–12 (1934).—Fifteen distinctive pieces of Lung Ch'üan celadon are described. Illustrated. A.A.A.

**Trustworthiness of J. T. Smith.** MRS. ARUNDELL ESDAILE. *Trans. English Porcelain Circle*, No. 4, pp. 26–44 (1932).—Smith's notes on Chelsea and Bow are discussed. His accuracy of statement is defended and questioned. H.S.

**Wallace Elliot's collection.** ANON. *Trans. English Ceram. Circle*, No. 3, pp. 97–98 (1935). H.S.

**Worcester porcelain figures.** WALLACE ELLIOT. *Trans. English Ceram. Circle*, No. 2, pp. 29–40 (1934).—E. attempts to confirm the belief that porcelain figures were made at Worcester. Illustrated. H.S.

### BOOKS

**Greek art from prehistoric times to the 18th Century.** (In French). C. ZERVOS. 368 plates. Cahiers d'Art, Paris; A. Zwemmer, London, 1935. Price 28s 6d. Reviewed in *Illus. London News*, **186**, 352 (March 2, 1935). The book is richly illustrated with vases, terra cottas, etc. H.H.S.

**Industrial art explained.** JOHN GLOAG. Allen & Unwin, London, 1935. Price 5s. Reviewed in *Discovery*, **16**, 121 (April, 1935).—G. proposes the formation of an Academy of Design, amalgamating all existing societies of this nature and serving as means of coördination between artists and manufacturers. H.H.S.

**Italian Renaissance.** Life and Art in Photograph. I. Edited by A. K. WICKHAM. Oxford University Press, 1935. Price $2.00. xvi + 104 pp., 104 illustrations. A brief anthology of the visual arts of the Italian Renaissance is presented in 104 full-page photographs. Ceramic pieces by Luca and Andrea della Robbia and Benedetto da Maiano are shown. Familiar examples of the work of many artists and craftsmen of this period are reproduced. The illustrations are clear and well-printed and provide excellent reference material for one not familiar with the period. HENRY H. SMITH

### Erratum

**Art and Archeology.** *Ceram. Abs.*, **14** [6] 132 (1935).—The first two lines under this heading should be read with the patent abstracts of the preceding section. EDITOR

### PATENTS

**Designs for:**

**Ash tray, etc.** J. B. CLARK (Indiana Glass Co.). U. S. 95,896, June 11, 1935 (March 18, 1935).

**Bottle.** J. L. DUNNOCK (Swindell Bros., Inc.), U. S. 95,900, June 11, 1935 (April 17, 1935). W. R. LEACH (Carr-Lowrey Glass Co.), U. S. 95,849, June 4, 1935 (March 29, 1935). FRANK MCLAUGHLIN (Carr-Lowrey Glass Co.), U. S. 95,854, June 4, 1935 (March 29, 1935). J. S. STEIN (Lucien Lelong, Inc.), U. S. 95,873, June 4, 1935 (Feb. 25, 1935). L. M. SUTTON, JR. (Hazel-Atlas Glass Co.), U. S. 95,937, June 11, 1935 (Feb. 18, 1935).

**Bowl.** M. A. SMITH. U. S. 95,783, May 28, 1935 (March 12, 1935).

**Coffeepot.** CHARLES KAISER (Morimura Bros., Inc.). U. S. 95,753, May 28, 1935 (Sept. 1, 1934).

**Cookie jar.** CHARLES KAISER (Morimura Bros., Inc.). U. S. 95,755, May 28, 1935 (Sept. 1, 1934).

**Creamer.** CHARLES KAISER (Morimura Bros., Inc.). U. S. 95,748 and 95,754, May 28, 1935 (Sept. 1, 1934).

**Cup.** CHARLES KAISER (Morimura Bros., Inc.). U. S. 95,751, May 28, 1935 (Sept. 1, 1934).

**Decanter, etc.** EUGENE STAHL (Fostoria Glass Co.). U. S. 95,872, June 4, 1935 (April 13, 1935).

**Fishbowl, etc.** C. P. ASKEW (Canton Glass Co.). U. S. 95,727, May 28, 1935 (March 19, 1935).

**Plate, etc.** CHARLES KAISER (Morimura Bros., Inc.), U. S. 95,752, May 28, 1935 (Sept. 1, 1934). C. W. LEIGH (Morimura Bros., Inc.), U. S. 95,760 and 95,761, May 28, 1935 (Sept. 1, 1934). C. L. SEBRING (Sebring Pottery Co.), U. S. 95,867, June 4, 1935 (Sept. 13, 1934).

**Sugar bowl.** CHARLES KAISER (Morimura Bros., Inc.). U. S. 95,750, May 28, 1935 (Sept. 1, 1934).

**Teapot.** CHARLES KAISER (Morimura Bros., Inc.). U. S. 95,749 and 95,756, May 28, 1935 (Sept. 1, 1934).

**Toilet.** G. C. DUNCAN, JR. (Duncan No-Noise Valve & Bowl Co., Inc.). U. S. 95,733, May 28, 1935 (March 16, 1934).

## Cements

**Chemistry of Portland cement.** L. FORSÉN. *Zement*, Nos. 2–3, p. 17 (1935); abstracted in *Verre & Silicates Ind.*, **6** [5] 89–90 (1935).—Minerals in clinker and their constitution are discussed. In fused mixtures of tetracalcium alumino-ferrite, tricalcium and pentacalcium aluminates, calcium and alkaline silicates, alkaline earths, and impurities, a dissolving of lime and siliceous materials or even $\beta$-dicalcium silicate already formed in the solid state is produced; the silicates, tricalcium and dicalcium silicate $\alpha$, separate in crystalline form. The upper limit for lime corresponds to tricalcium silicate and liquid, without free lime. The time available during the firing of cement is not sufficient to attain a final equilibrium. The compounds which crystallize first do not undergo further transformations during the manufacture of clinker; these modifications would require much longer heating. The upper limit for lime can be obtained for technical conditions of firing by the formula:

$3CaO{\cdot}SiO_2 + x(4CaO{\cdot}Al_2O_3{\cdot}Fe_2O_3) + y(nCaO{\cdot}Al_2O_3)CaO = 2.8\%\ SiO_2 + 1.4\%\ Fe_2O_3 + f(\%Al_2O_3 - 0.64\%\ Fe_2O_3)$

Because of the stability of tricalcium silicate and tetracalcium alumino-ferrite as well as the partial decomposition of tricalcium aluminate during the fusing in conditions of technical firing, the above formula is generally applicable for rotary kilns. The factor, $f$, varies according to the raw materials between 1 and 1.65. For materials rich in fluxes and iron oxide, the final equilibrium and theoretical maximum saturation in lime ($f$ = 1.65) can be reached both because of the solubility of lime in the flux of $4CaO{\cdot}Al_2O_3{\cdot}Fe_2O_3$ as well as the rapidity of reaction of these systems in industrial heating conditions. The formula of Bogue, generally accepted for the calculation of the constituents of clinker, $4\ CaO{\cdot}Al_2O_3{\cdot}Fe_2O_3 + 3CaO{\cdot}Al_2O_3 + 3CaO{\cdot}SiO_2 + 2CaO{\cdot}SiO_2$, which presupposes the attainment of the final equilibrium, can not be strictly applied for Portland cement clinkers. Only after the determination of residual fluxes in each raw material (without free lime) and with a microscopical mineral analysis can an exact expression of the mineralogical composition of different kinds of clinker be obtained. See also *Ceram. Abs.*, **12** [8] 291 (1933). M.V.C.

**Economics of magnesia Portland cement production.** V. E. SHNEIDER AND B. V. PETERS. *Zement* [U.S.S.R.], **2** [10] 37–44 (1934).—The production of Portland cement from dolomitized limestone opens possibilities for the development of the cement industry in new districts and for the improvement of the work of cement plants whose deposits of raw materials are characterized by an inhomogeneity of different layers of limestone. At a plant in the Moscow district the extraction of rock was reduced nearly one-half, labor and total costs were reduced, the plant was enlarged, and a high-grade cement was obtained. P.B. & E.S.

**Fused cement. III. Synthesis of $5CaO{\cdot}3Al_2O_3$ from calcium phosphate and aluminium phosphate.** KEI-ICHI AKIYAMA. *Jour. Soc. Chem. Ind.* [Japan], **37** [4] 173–74*B* (1934); for Part I see *Ceram. Abs.*, **14** [1] 3 (1935). M.V.C.

**Influence of fineness of grind on the quality of magnesia cement.** N. N. MIKHAILOV. *Stroitel. Material.*, No. 10, pp. 46–54 (1934).—Finer grinding leads to a better quality of building materials made with caustic magnesite, coarser grains possessing less activity as a binding material. P.B. & E.S.

**Pyrite oxidation.** GEO. W. BAIN. *Econ. Geol.*, **30** [2] 166–69 (1935).—A white marble which developed an orange stain in monuments and exterior building construction was found to have a fine vein structure of pyrite. Only in cases where Portland cement had been in contact with the marble did the stain develop. B. determined that oxidation of the pyrite was accelerated by sodium and potassium salts from the cement. The first alteration to ferrous sulfate, evidenced by a greenish color after four weeks' exposure, can be halted at this stage by treatment with barium chloride which forms an insoluble barite precipitate about the pyrite. If unchecked, the ferrous sulfate continues to form, migrates to the surface, and is there oxidized to ferric sulfate which eventually changes to ferric hydrate. The highly conducting form (electrical conductance) weathered more rapidly than the high-resistance type of pyrite, which was characterized by pyritohedral forms. All of the pyrite in the white marble which stained was of the low-resistance form with no pyritohedrons. Pyritohedral pyrite in contact with Portland cement for a long period showed no tendency to discolor. J.L.G.

**Thermal balance sheets of rotary kilns.** W. K. DEINEKA AND W. A. ZAKHAROV. *Zement* [U.S.S.R.], **2** [10] 25–36 (1934).—A detailed method of compiling balance sheets for rotary kilns is given. P.B. & E.S.

BOOK

**Portland Cement and Its Standardization.** P. E. BASHMACHNIKOV. State Pub. House on Standardization, Moscow and Leningrad, 1935. 112 pp. Price 2R. This book deals with (1) Portland cement in the general nomenclature of cement (binding) materials, (2) raw materials used in Portland cement manufacture, (3) methods of manufacture, (4) specifications, (5) physico-mechanical tests, (6) hydraulic additions, (7) grades, (8) uses, and (9) manufacture of Portland cement in U.S.S.R. The general text follows the All-Union Standards on Portland cement adopted in the U.S.S.R. (V.K.S.). S. I. PERKAL

## Enamel

**Conveyerized plant.** H. DANA CHASE. *Better Enameling*, **6** [5] 6–9 (1935).—A detailed description of the refrigerator plant of the General Electric Co. at Erie, Pa., is given. With the exception of a number of gravity-floor conveyers all the parts to be processed are handled by overhead conveyers. Illustrated. E.J.V.

**Copperheading in enamel; causes and methods of prevention.** J. J. CANFIELD. *Ceram. Ind.*, **24** [6] 362–66 (1935); *Better Enameling*, **6** [5] 12–14 (1935).—Copperheads are defects in enamel caused by local spots of excess iron oxide. After a discussion of what happens in firing an enamel, C. describes experiments in fusing a commercial enamel with iron oxide in crucibles with no iron present. Iron oxide crystals have been identified in copperhead structure, and since they raise the fusion point, it follows that the presence of the relatively infusible oxide crystals is the explanation for the infusible mass that exists in most copperheads. Some specific causes of copperhead defects are insufficient cleaning, thin enamel coat, metal surfaces, improper drying, heating rates, furnace atmospheres, enamel characteristics, and plant processing conditions. These are interrelated through obtaining the condition whereby excessive local oxidation may occur. Oxidation of the metal surface, which is generally considered necessary for the development of adherence, may occur under certain conditions to give defective ware. The oxide defects are a result of oxidation which overloads the ground coat, and preventive measures are those which control oxidation within low and desired limits. Illustrated. E.J.V.

**Copperheads.** H. HADWIGER. *Glashütte*, **65** [7] 95 (1935); abstracted in *Verre & Silicates Ind.*, **6** [5] 89 (1935).—Copperheads are the small crater-like hollows of a bright metallic appearance which occur in enamel. They are composed of iron oxide crystals with hematite predominating. Streaks of oxide are often found dissolved in the enamel around them. In the process, a local concentration of oxide or salt of iron lowers the fusing point of the base enamel so that at this point the enamel is fired while the rest of the piece is normal. If the mass of the enamel present is sufficient to dissolve $Fe_2O_3$, streaks are obtained and the piece can continue to be enameled; if not, the enamel is fired and the separation of red hematite crystals occurs which forms the copperheads. To avoid this defect, the sheet iron must be cleansed and rinsed thoroughly and its quality examined. M.V.C.

**Costing for vitreous enameling.** WILLIAM TODD. *Foundry Trade Jour.*, **51** [958] 401–403 (1934).—Factory costing may be arranged in four main groups: (*a*) industrial, for arranging wage rates and establishing industrial coördination, (*b*) technical, for establishing productive efficiency, (*c*) commercial for fixing selling prices, and (*d*) financial, for providing interim stock and work in progress values. The adoption of a uniform system of costing for the enameling industry is needed, and T. suggests that a good medium for the introduction of such a system would be the Institute of Vitreous Enamelers. See "Institute of Vitreous Enamelers," this issue. H.E.S.

**Defects in enameling.** J. NAPPÉE. *Verre & Silicates Ind.*, **6** [5] 85–87 (1935).—Defects in enameling and their most common causes are classified and listed in table form. See also *Ceram. Abs.*, **14** [3] 64 (1935). M.V.C.

**Economic conduct of vitreous enameling.** J. H. COUPE. *Foundry Trade Jour.*, **51** [958] 407–10 (1934).—Factors influencing costing of cast-iron enamel manufacture are outlined. Costing may vary in detail, but the general principles remain the same. Systems that are too elaborate are often very costly. C. advises manufacturers not to carry too heavy stocks and to avoid excess labor, especially of the nonproductive type. H.E.S.

**Electron microscope for observing the $\alpha$-$\gamma$ transformation of iron.** E. BRÜCHE AND W. KNECHT. *Z. tech. Physik*, **16** [4] 95–98 (1935).—By using cathode ray beams instead of light, the magnifying power of microscopes, in some cases, is increased. The structure of iron while being heated to various temperatures is shown. The transformation occurs suddenly over the entire sample, the temperature being 907°C when heating the sample, and 898°C when cooling. Iron containing 1% of silicon shows a transformation temperature of 927 and 918°C, respectively. W.M.C.

**Expansion behavior of cast iron.** E. SÖHNCHEN AND O. BORNHOFEN. *Arch. Eisenhüttenwesen*, **8**, 357–59 (1935).—Carbon shows the greatest influence on the coefficient of expansion of cast iron. Disintegration of carbide increases the coefficient of expansion, and large additions of nickel result in wide variations. Copper and aluminum will increase the coefficient, while chromium will first increase and then decrease it. W.M.C.

**Ferrites. Formation of a solid solution by some ferrites.** NOBORU KAWAI. *Jour. Soc. Chem. Ind.* [Japan], **37** [4] 174*B* (1934).—Mixtures containing two or three ferrites having the same lattice, $FeO{\cdot}Fe_2O_3$, $NiO{\cdot}Fe_2O_3$, $CoO{\cdot}Fe_2O_3$, $ZnO{\cdot}Fe_2O_3$, $CdO{\cdot}Fe_2O_3$, and $MgO{\cdot}Fe_2O_3$, in varying proportions were heated to sintering. The mixtures formed solid solutions and had a homogeneous structure. M.V.C.

**Fine-milled enamel slips.** F. R. PORTER. *Ceram. Forum*, **1** [9] 2 (1935).—By milling enamel cover-coat frits for a longer time a finer product is obtained which, in general, (1) increases the opacity 4 or 5%, (2) decreases about 25% the amount of enamel necessary, and (3) requires a lower firing temperature. The chief objection to finer frit is that ware covered with it requires careful handling to prevent starring and tearing. See also *Ceram. Abs.*, **14** [3] 64 (1935). M.C.S.

**Hard-soldering of ferrous and nonferrous metal parts and its importance for foundries.** ERICH BECKER. *Giesserei*, **22** [9] 195–98 (1935).—Advantages of hard-soldering with oxyacetylene flame, not only for repairing but also for joining parts in place of welding, are discussed, the lower temperature being especially advantageous as the joint can more easily be freed of pores and interior stresses. The solder for cast iron is usually a mixture of 60% Cu and 40% Zn; additions of 1% Sn, 1 to 1.5% Fe, or about 1% Mn, and especially Si improve the strength of the soldered joint. Pb is always harmful, making the joint porous and brittle. Alloys of Cu-Ni, also used as solders, have a color more resembling cast iron and are more heat-resisting than brass. Al is hard-soldered with

solders containing 70 to 95% Al and additions of Cu, Zn, Sn, Si, Ni, Mn, Cd, Ag; they are applied at 550 to 630°C while Al is welded at 660°. Ni and Ni alloys are soldered with German silver and silver solders with low Zn content and Ni of such amount that they have a white color; the melting temperature should be between 700 and 800°C. The best procedure and fluxes are discussed with particular attention to work in molding and foundry work. 16 references. M.H.

**Institute of Vitreous Enamelers.** ANON. *Foundry Trade Jour.*, **50** [921] 234–36 (1934).—The proposed Institute of Vitreous Enamelers was ratified, officers were elected, and a constitution was drafted at a meeting of members of the vitreous enameling industry and suppliers at the Birmingham [England] chamber of commerce, March 28, 1934. The Institute was organized for the following objects: (*a*) to provide a means of bringing into personal contact individuals engaged in the vitreous enameling industry; (*b*) to provide facilities for the statement, discussion, and elucidation of scientific and technical problems arising in all processes involved in vitreous enameling; (*c*) to establish for the optional use of firm members a registered mark or symbol signifying "genuine vitreous porcelain enamel"; (*d*) to afford a channel for making representation to government bodies, in respect to matters appertaining to the welfare of the industry; (*e*) to coöperate with other institutes, societies, and associations in the furtherance of this purpose. H.E.S.

**Light castings for enameling.** H. B. MCNAIR. *Foundry Trade Jour.*, **50** [915] 148–51 (1934).—The problem of the practical foundrymen is to produce castings free from distortion and breakage during the enameling process and free from surface defects or inclusions likely to interfere with the application of the enamel or the properties of the finished product. The first is a question of design and strength of material while the second may be traced to one of three sources: (1) The heat and flow of the iron cause erosion of the mold, and the dirt so formed will rise to the upper surface of the metal, accumulate, and form a dirty patch on the surface. (2) The metal generates steam from the moisture in the facing sand, resulting in a surface oxidation accompanied by a liberation of hydrogen, the latter escaping through the vents of the mold. Such oxidation results in a scale similar to that formed on wrought iron. (3) The trouble may be due to impurities in the materials charged, oxidation during melting with the formation of complex oxides, and slag mechanically retained by the metal. The trouble can be largely avoided by de-oxidation or desulfurization of the iron and the maintenance of suitable clean sand that is strong and permeable. H.E.S.

**Mechanized foundry of Sterling Manufacturing Co. (enameling department).** V. C. FAULKNER. *Foundry Trade Jour.*, **50** [926] 313–16 (1934).—F. describes a modern English enamel shop in which both sheet-iron and cast-iron enameling are done. This company enamels mangles, wringers, domestic coke boilers, electric burners, gas irons, gas burners, water softeners, gutters, rainwater pipes, gas cookers, fire grates, tombstones, cooker splash plates, flue pipes, geysers, jam boilers, roof tile, refrigerators, shelves, and sinks. Diagrams and illustrations. H.E.S.

**Physical and chemical principles in mixing iron ore and fluxes. II.** J. KLÄRDING. *Arch. Eisenhüttenwesen*, **8**, 325–28 (1935).—The best mixing method for iron oxide, lime, and alumina was found to be a ratio of 1:1 for lime to alumina. Alumina may be considered as an acid in the reduction of iron oxide by lime. Dicalcium ferrite is not stable over a wide range if alumina is present. Spinel occurs as a stable phase up to a high lime excess, while the oxygen content of the solid phase is low. For Part I see *Ceram. Abs.*, **14** [6] 151 (1935). W.M.C.

**Porcelain enamel in modern design.** J. O. REINICKE. *Better Enameling*, **6** [5] 10–11 (1935).—A wider and better use of porcelain enamel will logically follow the application of correct modern design. Illustrated. E.J.V.

**Production records.** H. E. MARTIN. *Enamelist*, **12** [8] 31–34 (1935); see also "Improved—" *Ceram. Abs.*, **14** [7] 157 (1935). E.J.V.

**Relation between chipping and thickness of porcelain enamel coatings.** H. H. HOLSCHER. *Ceram. Ind.*, **24** [6] 348–49 (1935).—The losses in a group of enamel parts with thickness above 0.021 in. are nearly seven times those with thicknesses below 0.018 in. or six times those with thicknesses below 0.021 in. The control of enamel thickness offers a means of reducing enamel losses, particularly those due to chipping. E.J.V.

**Relation between cobalt and nickel-oxide content and reboiling of sheet-steel ground coats.** J. M. CAYFORD AND R. M. KING. *Jour. Amer. Ceram. Soc.*, **18** [7] 224 (1935).

**Selecting the sheet metal and designing the product for enamel.** CHICAGO VITREOUS ENAMEL PRODUCT CO. *Better Enameling*, **6** [5] 15–19 (1935).—Difficulties encountered due to unsuitable metal base for porcelain enamel are listed. As important as selecting the proper sheet metal is the selection of the proper gage metal, the design, and the forming, punching, or shearing of the product to be enameled. Sharp corners should be eliminated. In welding, care must be taken to maintain uniform thickness throughout. If a product is to be assembled, consideration must be given this when designing individual parts. Illustrated. E.J.V.

**Single cover-coat demands changes and control in enameling processes.** G. L. BRYANT. *Ceram. Ind.*, **24** [6] 354 (1935).—In developing a one cover-coat process, the first requirement is a good grade of enameling iron which has been inspected and tested before use. Thorough cleaning and a hard pickling with thorough rinsing after each tank, a rigidly inspected ground coat, an ultra-opaque cover enamel, thorough drying before handling, and a close check on the weight of the sprayed enamel applied to the ware are other requirements for satisfactory results. E.J.V.

**Small causes, large effects.** H. HEIMANN. *Ceram., Verrerie, Émail.*, **2** [3] 121–22 (1934).—Enamel frits stored in a room adjoining the iron-cleaning room led to a loss of brilliance and a poor color in the enamel due to the attack of the tin oxide and borax by the hydrochloric acid fumes. M.H.B.

**Spoiled ware of the foundry and its influence on enamel.** V. YA. LOKSHIN AND I. S. EGIZ. *Liteinoe Delo*, **6** [1] 35–40 (1935).—The chemical composition of cast irons for castings is discussed, and analyses of German, English, American, Czechoslovak, Austrian, and U.S.S.R. castings

are given. The defects encountered in cast-iron ware due to different causes (molding and casting, construction, and incorrect storing of the raw castings) are discussed in detail. A summary is given embracing twenty-one defects in iron castings used for enameling under the following headings: name of defect, cause, and its influence on enamel. A range of defects is illustrated (15 figs.). S.I.P.

**Tempering cast iron by means of nitrogen.** A. N. DOBROWIDOW AND N. SCHUBNI. *Arch. Eisenhüttenwesen*, 8, 361–63 (1935). W.M.C.

**Vibration for eliminating orange peel.** C. S. HOUPT. *Enamelist*, 12 [8] 24 (1935).—To overcome a wavy orange-peel surface, a vibrating machine using air vibrators in connection with a frame upon which parts to be operated are placed and fastened before vibrating has been developed. Sprayed enamels gave better results when slightly more fluid than the standard specific gravity, while dipped ground coats responded readily to vibration at standard weight. A brief vibration period is used, care being required to prevent over-vibration which may produce a dull or semi-mat finish, while in some colored enamels the uniformity of the color is destroyed. E.J.V.

**Vitreous enameling of cast iron.** B. B. KENT. *Foundry Trade Jour.*, 51 [956] 375–77 (1934).—A description of the wet process of cast-iron enameling is given in which careful control and cleanliness are practiced. The process is divided into (*a*) cleaning the castings, (*b*) preparing the liquid enamel, (*c*) spraying and drying the castings, and (*d*) fusing and firing. H.E.S.

**Vitreous enameling on cast iron and sheet steel.** A. ENGLAND. *Foundry Trade Jour.*, 51 [946] 207–10 (1934).—A history of the development of cast-iron and sheet-steel enameling is given. E. predicts that the enamel industry of the future will be highly specialized, one plant making one article only, *i.e.*, a particular type of cooking ware, sink, etc. He suggests that the Institute of Vitreous Enamelers publish a proceedings containing definite information on enameling problems. H.E.S.

**White enamel for cast iron.** L. VIELHABER. *Emaillerie*, No. 12, p. 9 (1934); abstracted in *Verre & Silicates Ind.*, 6 [4] 69 (1935).—The composition of a white enamel, a single coat of which suffices for cast iron (used for pieces not intended for cooking ware because of the high lead content) is borax 16, feldspar 1.5, litharge 48, quartz 24, cryolite 5, fluorspar 1.5, and magnesium carbonate 4. Additions to the mill are pipe clay 7%, opacifier other than $SnO_2$ 7%, and borax 6%. If bubbles are formed, the lead content must be reduced and the additions to the mill increased by means of a ground frit (quartz and borax). M.V.C.

### Errata

**Hommelaya process of enameling.** J. E. ROSENBERG AND W. J. BALDWIN. *Ceram. Abs.*, 14 [6] 134 (1935).—In the second line, read "a compound of cobalt" for "a compound of steel." EDITOR

**Enamel.** IGNAZ KREIDL. Ger. 601,992, Aug. 29, 1934; *Ceram. Abs.*, 14 [6] 134 (1935).—In the last line, read "$SnO_2$" instead of "$nO_2$". EDITOR

### PATENTS

**Combinations of enamel and sprayed metal.** I. V. BRUMBAUGH. U. S. 2,004,567, June 11, 1935 (Sept. 8, 1933).

**Light-reflecting devices for signs, signals, etc.** STOCAL ENAMELS, LTD., AND W. S. GRANGER. Brit. 427,833, May 15, 1935 (Jan. 18, 1934).

**Manufacture of enamel opacifier.** C. ARNOLD (Harshaw Chemical Co.). Brit. 427,850, May 15, 1935 (July 9, 1934).

**Method of enameling.** W. G. MARTIN (A. O. Smith Corp.). U. S. 2,004,632, June 11, 1935 (June 11, 1934). In the art of vitreous enameling ferrous metals by a wet process, the step of improving the physical properties of such an enamel when applied to non-enameling iron and steel stock consists in fusing the enamel in an atmosphere substantially devoid of free oxygen, water-vapor, and hydrogen and containing a mixture consisting principally of nitrogen, carbon dioxide, and carbon monoxide.

**Method of producing ornamental enamelware.** A. C. WEIERICH (Vitreous Enameling Co.). U. S. 2,002,806, May 28, 1935 (July 30, 1932).

**Tile.** HARRY MARCH AND R. M. CHESNEY (Porcelain Tile Corp.). U. S. 2,005,380, June 18, 1935 (Sept. 26, 1932).

## Glass

**Calculating fuel requirements of a continuous glass tank.** J. W. ROMIG. *Glass Ind.*, 16 [6] 169–70 (1935).—Four methods of calculating fuel requirements of a glass tank are listed. The method in which heat losses are computed by the use of thermal conductivities is explained in detail. E.J.V.

**Composition of glass.** VLAD. DANEŠ. *Sklářské Rozhledy*, p. 102 (1933).—In D.'s opinion, glasses are substances with a somewhat different molecular structure than that of solid crystalline substances. The intramolecular forces cause the formation of large molecular complexes of insufficient symmetry. It is a matter of opinion whether these complexes are called micellae (colloidal particles covered with a film of noncolloidal matter which has formed from them), macro-molecules (molecular agglomerates formed by association of molecules at the temperature of aggregation), or solvation aggregates (mutual solutions of different compounds, but no ideal solution; the electric charges of the components interact at high temperatures and the effect of this interaction may be compared with the solvation of real liquid solutions). The properties and stability relations of glasses depend to a very high degree on temperature. R.B.

**Course in glassmaking. Optical glasses.** ANON. *Verre & Silicates Ind.*, 6 [4] 67–68 (1935).—The discovery of coal and its use in glass factories necessitated changes in furnace construction and the glass batch. The idea of replacing lime with lead oxide to improve the quality of the glass had remarkable consequences. Guinand discovered the means of making the industrial preparation of flint glass possible, and then Strass discovered the glass that bears his name. The composition and properties of

flint and crown glasses are given. *Ibid.*, **6** [8] 141–44 (1935).—Glass for chemical apparatus must be resistant to chemical agents and sudden changes in temperature; it must be hard to fuse and have a low alkali content and low coefficient of expansion. The composition and properties of a Bohemian, Jena, Thuringian, and Pyrex-brand glass are given with a brief outline of the manufacture of thermos bottles, electric light bulbs, tubes for gages, etc., glass beads, glass thread, and "cotton." M.V.C.

**Depth of heat penetration in molten glass with luminous and nonluminous flames.** F. G. SCHWALBE. *Ind. Heating*, **2** [2] 99–102; [3] 153–54; [4] 209–10 (1935).—The radiation differences of luminous and nonluminous flames are explained, and radiation laws and energy transmission in glass at elevated temperatures are discussed. Data are given for various colored glasses and for heat penetration in glass of different colors, and the effects of the temperature of glass on its transmission properties are investigated. Examples illustrate the use of data and curves. See also "Luminous—," *Ceram. Abs.*, **14** [5] 124 (1935). M.H.

**Determining ferrous iron in glass.** SHIGEYUKI SHINKAI AND KUSUHIKO TAKAHASHI. *Jour. Soc. Chem. Ind.* [Japan], **38** [4] 133*B* (1935).—The source of error in Cooke's method for the determination of ferrous iron in glass was thought to be the presence of As in glass and not HF as was formerly believed. To eliminate the $AsF_3$, the solution was heated to 120 to 130°C in air, and the results, which were satisfactory, are given in a table. M.V.C.

**Determining iron and titanium in window glass.** GANTOIS, LEJEUNE, NOËL, AND SCOHY. *Verre & Silicates Ind.*, **6** [5] 78–81; [6] 97–99 (1935).—The gravimetric method, starting with the disintegration of alkaline carbonates, yields results that are much too high. The sulfohydrofluoric method gives results which agree with those of the colorimetric methods. The most suitable method for the determination of iron in glass is the colorimetric process either by ferrocyanide and ferricyanide of potassium or by potassium sulfocyanide. For the determination of titanium in glass, the colorimetric determination with hydrogen peroxide is preferred. The gravimetric determination gives satisfactory results but requires greater care and attention than the colorimetric process. Also in *Bull. soc. chim.*, **43**, 545 (1934). M.V.C.

**Diaphragm separators of glass silk for electric accumulators.** ANON. *Verre & Silicates Ind.*, **6** [6] 104 (1935).—Diaphragms of glass silk are perfect electric insulators and can be applied directly on the plates of accumulators which are thus prevented from buckling or disintegrating and whose life period is thereby increased. The porosity of glass silk separators does not hinder the free passage of electric ions or interfere with the normal functioning of accumulators. M.V.C.

**Effect of lithium oxide on thermal expansion of glass.** LOUIS NAVIAS. *Jour. Amer. Ceram. Soc.*, **18** [7] 206–10 (1935).

**Electrical exhibits at Leipzig Fair.** G. A. BLUME. *Eng. Progress*, **16** [4] 97 (1935).—Glass fused to ceramic materials produces gas- and liquid-tight joints. Glass windows can be fused in ceramic apparatus. Using glass as a medium, electrical conductors can be fused into ceramic bodies. Photos of steatite sealed to lead glass are shown. Materials having a dielectric constant up to 80 have been made using a titanium dioxide base. J.L.G.

**Filter for obtaining light at wave-length 560 mμ.** KASSON S. GIBSON. *Jour. Research Nat. Bur. Stand.*, **14** [5] 545–52 (1935); R.P. 786. Price 5¢. A new 4-component glass filter has been designed which isolates and transmits light at 560 mμ more effectively than previous filters. Two components of this filter are of Corning glass and two of Jena glass. R.A.H.

**Fine grinding of glass by means of sand and water.** K. POETZL. Abstracted in *Verre & Silicates Ind.*, **6** [6] 109–10 (1935).—Tests were made on an ordinary grinding machine on a homogeneous glass without tensions; an ordinary grinding sand with the addition of water during operation was used as abrasive. The results are given in tables, graphs, and formulas, and can be summarized as follows: The quantity of glass removed depends on the grinding pressure which must not exceed a certain limit; the rate of grinding between 2 and 6 m./sec. has no effect on the quantity of glass removed. M.V.C.

**Fundamental reactions in the formation of soda-lime-silica glasses.** J. T. HOWARTH, R. F. R. SYKES, AND W. E. S. TURNER. *Jour. Soc. Glass Tech.*, **18** [72] 290–306 (1934).—Mixtures of fine-grained quartz, calcite, and sodium carbonate in the molecular proportions $Na_2CO_3 + CaCO_3 + SiO_2$, $Na_2CO_3 + CaCO_3 + 4SiO_2$, $Na_2CO_3 + CaCO_3 + 6SiO_2$, and $Na_2CO_3 + CaCO_3 + 8SiO_2$ were heated at temperatures ranging from 600 to 1400°, the rate of reaction being ascertained at intervals in the range from 600 to 900°. This rate increased rapidly with rise in temperature; thus for the $Na_2CO_3 + CaCO_3 + 6SiO_2$ mixture, the extent of decomposition was 9.5% in 100 min. at 600°, 95% in 100 min. at 800°, and nearly 100% in 10 min. at 900°. The rate of reaction also increased with the proportion of silica present. In the lower temperature range, up to about 750°, the principal reaction was apparently the decomposition of calcite, but at 775°, when fritting occured at an appreciable rate, the reaction $Na_2CO_3$–$SiO_2$ became prominent, as indicated also by microscopic examinations of the products of heating. The $4SiO_2$ mixture melted to a glass more rapidly than the $6SiO_2$ mixture. Experiments made with mixtures of commercial materials indicated that the rate of reaction at the lower temperatures remained about the same but, due to the larger grain size of the materials, became relatively slower as the temperature was increased. A.A.

**Glass bends like steel.** LIBBEY-OWENS-FORD GLASS CO. *Nat. Glass Budget*, **51** [2] 3 (1935); *Ceram. Ind.*, **24** [6] 338–41 (1935); see "Tough—," *Ceram. Abs.*, **14** [3] 67 (1935). M.C.S.

**Glass colors produced by rare earths.** G. HTH. *Glas & App.*, **15**, 115 (1933); abstracted in *Jour. Soc. Glass Tech.*, **18A**, 199 (1934).—The colors produced by some of the rare earths have been known for some time, and Drossbach recommended the use of neodymium or erbium as decolorizing agents at the end of the last century. Cerium or praseodymium in these materials imparted a bluish tint to the decolorized glass if the iron were in the ferrous condition, but gave good correction with ferric glasses. Rare earths intended for decolorizing should be free from

praseodymium. The special two-color effects were best obtained with mixtures of the oxides of Nd and Pr, since didymium contained them in the ratio of 3:1 to 6:1 instead of the necessary 4:3 to 3:5 (as described in Ger. 572,876 (*Ceram. Abs.*, **13** [2] 38 (1934)).

**Glass enters a new age.** ARTHUR POUND. *Atlantic Monthly*, **155** [6] 763–71 (1935).—A history and a description of the Libbey-Owens-Ford Glass Co. are given. A.P.

**Glass in illuminating engineering and the determination of some of its fundamental properties.** V. ČTVROKÝ. *Zprávy Československ. keram. společnosti*, **10**, 13 (1933).—Good qualities of illuminating lamps are described. Three-layer glasses, using crystal, opal, and crystal layers are most successful in diffusing the light and give good reflection. Some photometers are described. The average efficiency of good Czechoslovak illuminating glass is 90 to 95%. R.B.

**Glass as substitute for base metals.** ZIENER. *Clas & App.*, **16** [9] 77–78 (1935).—The many uses for which glass can profitably replace base metals in apparatus, utensils, etc., especially in the laboratory and shop, are discussed, and mechanical properties of glass and metals are compared. However, the importance of the necessity of working glass in such cases exactly as metals is pointed out. M.H.

**Glassmaking in Mexico.** J. B. NEALEY. *Class Ind.*, **16** [6] 171–73 (1935).—A detailed description of the Vidrien Monterrey, S.A., glass plant in Monterrey, Mexico, is presented. Glass bottles, tableware, laboratory vessels, and plant glass in all colors are made here. Illustrated. E.J.V.

**Insulating properties of amber, silica glass, and sulfur in dry and moist air.** W. GNANN. *Physik. Z.*, **36** [7] 222–30 (1935).—New determinations of the dielectric characteristics have been made. The electric insulating properties of silica glass equal those of amber in dry air, but they are inferior in moist air. Sulfur is preferred when drying is not possible. W.M.C.

**Kinetic theory of glassy state and abnormal properties of glass.** O. K. BOTVINKIN. *Trans. Sixth Mendeleiev Congr.*, **2** [1] 451 (1935).—The glassy state is a general property of matter. The abnormal properties of glasses are general properties of substances in the glassy state. In the abnormal interval, aggregation of the molecules of liquid takes place accompanied by the loss of forward motion of the molecules. The change of physicochemical properties of glasses in the abnormal interval follows the Maxwell curve of distribution. The abnormal interval is a result of different velocities of motion of separate molecules of liquid. At a viscosity of $10^{13}$, all substances in the glassy state are in corresponding states; therefore a connection between melting temperature and $T\eta = 10^{13}$ is observed. Below $T_{\eta} = 10^{13}$, the process of crystallization is impossible. Below $T = 10^{13}$, from the kinetic point of view, the molecules of glass are in the same position as in crystals and therefore may reveal elastic properties, brittleness, etc. S.I.P.

**Largest telescope mirror of forty years ago.** FRANK W. PRESTON. *Glass Ind.*, **16** [6] 178–79 (1935).—In 1895 the Standard Plate Glass Co., Butler, Pa., cast a 62-in. blank to be made into a telescope mirror. John Peate, an itinerant preacher, using apparatus and machinery of his own devising, ground and polished the glass in a little over two years. The calculations were made by Peate and when the lens was moved to the Smithsonian Institute in 1934, experts of the Geophysical Laboratory and of Mt. Wilson Observatory said that it could be used with perfect satisfaction today if properly mounted. Illustrated. E.J.V.

**Materials for glass molds.** ANONYMOUS. *Glass Ind.*, **16** [6] 180–81 (1935).—A glass mold material should (1) be close grained and of a uniform texture, (2) be able to resist pitting and scaling even when operated at temperatures around 1500°F, (3) not warp or show excessive growth during use at normal operating temperatures, (4) possess a high thermal conductivity, (5) be easily machineable by both hand and machine methods, and (6) be economical. Types of iron and alloys used for glass molds are discussed. E.J.V.

**Physicochemical reactions in the mechanical working of glass.** JACQUES WOLF. *Ceram., Verrerie, Émail.*, **2** [3] 109–14 (1934).—Mechanical engraving or frosting of glass is accomplished by sandblasting or by friction with a grinding material. A chemical reaction results between the water used for grinding and the glass, the reaction varying with the type of glass used. Strains are frequently set up in the glass due to localized heating while grinding. M.H.B.

**Properties of mixed alkali-lime-silica glasses containing lithia, soda, potash, and rubidia.** S. C. WATERTON AND W. E. S. TURNER. *Jour. Soc. Class Tech.*, **18** [72] 268–85 (1934).—Using purified materials, four series of glasses were prepared having the general formula, 75 $SiO_2$, 10 CaO, 15% ($R'_2O + R''_2O$), in which the mixtures of alkalis used were, respectively, ($Li_2O + Na_2O$), ($Li_2O + K_2O$), ($Na_2O + K_2O$) and ($K_2O + Rb_2O$), and in which each oxide content varied from 0 to 15%. The curves relating composition with density and thermal expansion, respectively, were, in the first three cases, composed of two intersecting straight lines; the change of direction was most marked in the first series containing the oxides of lowest molecular weight. The breaks occurred at the molecular ratios $Li_2O$:$2Na_2O$, $Li_2O$:$2K_2O$, and $Na_2O$:$K_2O$. The corresponding curves for the ($K_2O + Rb_2O$) glasses were continuous straight lines. The $Li_2O$-containing glasses had the greatest coefficients of expansion, the other oxides in diminishing order being $Na_2O$, $K_2O$, and $Rb_2O$. The expansion curves for the glasses containing $Li_2O$, $Na_2O$, and $K_2O$ included three transition points, except for the 15% $K_2O$ glass which, together with the ($K_2O + Rb_2O$) series, showed two transition points. The softening point of the glasses rose in the order $Li_2O$, $Na_2O$, $K_2O$, and $Rb_2O$. A glass containing 15% $Cs_2O$ could not be melted even at 1650°. A.A.

**Rate of melting and refining of alkali-lime-silica glasses containing both soda and potash.** W. MASKILL AND W. E. S. TURNER. *Jour. Soc. Glass Tech.*, **18** [72] 286–89 (1934).—Meltings of a series of glasses of the composition $75SiO_2$, 10CaO, 15% ($Na_2O + K_2O$) indicated that the rate of melting was a maximum when both alkaline oxides were present, although the refining of such glasses did not occur more quickly than in the case of the soda-containing glass. The glass containing potash required a

temperature of only 1500° for satisfactory melting and refining when melted in covered pots. The glasses containing both alkalis had better working properties than those containing either soda or potash alone, the most satisfactory glass being that which contained equal proportions by weight of soda and potash. A.A.

**Rate of setting of glass during working.** I. I. KITAIGORODSKIĬ AND N. W. SOLOMIN. *Jour. Soc. Glass Tech.*, **18** [72] 323–35 (1934).—As a measure of the rate of setting of glass the symbol, $Z$, was suggested, corresponding to the time interval during which the viscosity increased from the initial to the final value while the glass was being worked. Two colorless glasses of high and low heat capacities, respectively, were studied; the former glass had a lower thermal conductivity than the latter. The values of $Z$ in seconds under the conditions of experiment were 126 and 117. Glasses colored with cobalt, ferric, and ferrous oxides cooled more quickly on the surface due to their greater radiating powers. A glass containing manganese oxide differed little from the colorless glass. For each of the colored melts the base glass was the latter of the two mentioned above. A.A.

**Reflections.** TERDES. *Céram., Verrerie, Émail.*, **2** [12] 514 (1934).—T. assails the glass industry for using old methods. M.H.B.

**Selenium: its use in decoloring glass.** R. D. AND L. F. *Verre & Silicates Ind.*, **6** [7] 118–20; [8] 137–40 (1935).—The color produced by selenium in glass varies according to the degree of oxidation; from colorless it turns to rose, then to brown, and finally becomes colorless again. The purest tint is given by elementary selenium in neutral atmosphere. The behavior of selenites, selenides, and selenium under different conditions and in different glass batches is given in detail. M.V.C.

**Sioto in glassmaking.** ANON. *Verre & Silicates Ind.*, **6** [6] 104–106 (1935).—Sioto, a pulverized commercial product, is a silicate with an alkali, alumina, baryta, and boric acid base which is added as a raw material to facilitate fusion and refining. It may partly replace potash, soda, or even borax. Tests on its use in different glass batches are described, and the results obtained and the properties of Sioto are given. M.V.C.

**Spun glass as insulating material.** JACK BROOKS. *Ceram. Ind.*, **24** [6] 353 (1935).—Results of low-temperature and heat-loss tests on spun glass or glass silk as an insulating medium compare well with those of older types of insulating material. It is not affected by extremes of cold and has resisted processes of disintegration at 1100°F. Its use obviates frequent renewal of the insulating media due to vibration and, being nonhygroscopic, it resists corrosion to a high degree. It is also valuable as a sound-insulation medium. The method of manufacture is described. E.J.V.

**Symposium on standardization of glassware.** ANON. *Céram., Verrerie, Émail.*, **2** [11] 489–90 (1934).—A symposium on the standardization of glassware was held in France in October, 1934, under the direction of M. Cellerier. No proceedings are given. M.H.B.

**Time factor in testing glassware.** F. W. PRESTON. *Jour. Amer. Ceram. Soc.*, **18** [7] 220–24 (1935).

BULLETIN

**Standard specifications for scientific glassware.** ANON. *Brit. Standards Inst. Bull.*, Nos. 571 and 572, London, 1934. Price 2s each. Reviewed in *Analyst*, **60**, 42 (Jan., 1935).—*Bulletin* No. 571 refers to distillation flasks and No. 572 to ground glass joints. H.H.S.

PATENTS

**Annealing sheet glass.** W. L. MONRO (American Window Glass Co.). U. S. 2,002,544, May 28, 1935 (Sept. 8, 1934).

**Apparatus for drawing glass.** W. O. AMSLER (Simplex Engineering Co.). U. S. 2,003,525, June 4, 1935 (Nov. 1, 1933).

**Apparatus for manufacturing vitreous products by drawing or rolling.** SOC. ANON. DES MANUFACTURES DES GLACES ET PRODUITS CHIMIQUES DE ST.-GOBAIN, CHAUNY, ET CIREY. Brit. 428,198, May 22, 1935 (Dec. 14, 1933); addition to Brit. 400,472, Nov. 1, 1933.

**Automatic glass feed.** C. G. HILGENBERG AND C. B. GARWOOD. Brit. 428,123, May 22, 1935 (Nov. 9, 1934).

**Decorated glass article.** E. C. LEIBIG (Corning Glass Works). U. S. 2,002,900, May 28, 1935 (Jan. 6, 1933).

**Fused bifocal lens.** E. CULVER AND A. H. EMERSON. Brit. 427,736, May 15, 1935 (Oct. 20, 1933).

**Glass feeder.** R. A. CHILCOTE (McLaughlin Glass Co.). U. S. 2,005,494, June 18, 1935 (Jan. 17, 1933). THOMAS STENHOUSE (Hazel-Atlas Glass Co.). U. S. 2,003,058, May 28, 1935 (Oct. 29, 1932).

**Glass-grinding machine.** M. R. SCHOTTLAND AND R. A. FONTAINE. U. S. 2,003,905, June 4, 1935 (Sept. 13, 1932).

**Glass-transfer apparatus.** J. C. E. SCHWAB (Hazel-Atlas Glass Co.). U. S. 2,004,349, June 11, 1935 (June 13, 1933).

**Glass-feeding apparatus.** DAVID STENHOUSE (Hazel-Atlas Glass Co.). U. S. 2,004,017, June 4, 1935 (Aug. 5, 1932).

**High-speed bottle making process.** H. W. INGLE (Hartford-Empire Co.). U. S. 2,003,940, June 4, 1935 (Jan. 22, 1932).

**Laminated glass.** J. C. ZOLA (Duplate Corp.). U. S. 2,003,330, June 4, 1935 (Feb. 17, 1934).

**Laminated glass and process of making.** B. J. DENNISON (Duplate Corp.), U. S. 2,005,075, June 18, 1935 (Aug. 18, 1934). E. L. FIX AND B. J. DENNISON (Duplate Corp.), U. S. 2,003,288, June 4, 1935 (June 28, 1934).

**Method and apparatus for drawing glass.** W. J. WOODS (Corning Glass Works). U. S. 2,002,875, May 28, 1935 (May 24, 1933).

**Method and apparatus for making glass articles.** H. A. FISHER AND J. P. LINDSAY. U. S. 2,005,519, June 18, 1935 (July 6, 1933).

**Method and apparatus for production of glass wool, etc.** W. W. TRIGGS (Owens-Illinois Glass Co.). Brit. 428,720, May 29, 1935 (March 2, 1934).

**Methods of manufacturing mirrors.** NAAMLOOZE VENNOOTSCHAP PHILIPS' GLOEILAMPENFABRIEKEN. Brit. 427,860, May 15, 1935 (Sept. 19, 1933).

**Manufacture of safety glass.** G. B. ELLIS (Soc. des usines chimiques Rhone-Poulenc), Brit. 428,548, May 29,

1935 (Nov. 27, 1933). C. W. BONNIKSEN (Protectoglass, Ltd.), U. S. 2,004,518, June 11, 1935 (Sept. 23, 1933).

**Process and apparatus for bending glass sheets.** R. A. MILLER (Pittsburgh Plate Glass Co.). U. S. 2,003,383, June 4, 1935 (Dec. 18, 1933).

**Process for making plate glass.** FREDERICK GELSTHARP AND W. G. KOUPAL (Pittsburgh Plate Glass Co.). U. S. 2,003,289, June 4, 1935 (June 30, 1933).

**Rotating basins forming gathering chambers annexed to glass furnaces.** SOC. ANON D'ÉTUDES ET DE CONSTRUCTIONS D'APPAREILS MÉCANIQUES POUR LA VERRERIE. Brit. 427,874, May 15, 1935 (Sept. 20, 1934); addition to Brit. 412,847, July 11, 1934.

**Suction glass gathering device.** P. L. GEER, H. A. MOORE, AND W. A. MORTON. U. S. 2,002,889, May 28, 1935 (April 7, 1932).

**Warning lights for use on electrically propelled road vehicles.** SUNBEAM MOTOR CAR CO., LTD., AND G. MATTHEWS. Brit. 428,547, May 29, 1935 (Nov. 27, 1933).

## Structural Clay Products

**Bricklayers needed.** E. F. GALLAGHER. *Brick Clay Rec.*, **86** [5] 171–72 (1935).—G. points out that the ranks of bricklayers have been depleted during the building lull and no newcomers have come in. Ways for replenishing the supply are suggested. E.J.V.

**Combating frame cracks in brick.** N. NAUMOV. *Stroitel. Material.*, No. 10, pp. 13–17 (1934).—In brick dried in artificial driers, cracks that form in the places where the brick repose on the frames are a serious problem. The formation of cracks can be explained by the fact that the parts lying on the framework dry more slowly because it is more difficult for air to reach them. To facilitate air circulation, the framework was strewn with sawdust, which reduced the number of cracked brick from 80% to 20 to 40%. P.B. & E.S.

**Drain tile for arid farm lands.** J. H. STOUT. *Brick Clay Rec.*, **86** [5] 168 (1935).—The possibilties of drain tile for use in sub-irrigation systems provide a new market which is discussed and recommended to drain-tile manufacturers for study. E.J.V.

**Gas permeability of building materials.** P. S. FILOSOPOV AND I. G. EFIMOVA. *Stroitel. Material.*, No. 10, pp. 41–46 (1934).—Experiments with different building materials showed that there is no direct proportional dependence between air permeability of the sample tested and its size and the pressure of the air. A higher humidity content of the material leads to a lowering of its permeability to air. Standard materials and standard samples should be taken for the tests. The following formula can be used for computing the rate of air permeability: $g = \frac{L \cdot D}{H \cdot P \cdot S}$, where $L$ = liters of gas passed in 1 hr., $D$ = thickness of sample in m., $H$ = time in hr., $P$ = air pressure of the water column in mm., and $S$ = area of section of sample in sq. m. The final result is obtained from an average of five measurements. P.B. & E.S.

**Paving brick.** J. ANDRÉ LAVERGNE. *Rev. mat. constr. trav. pub.*, No. 296, pp. 81–85*B* (1935).—Absorption tests on paving brick were made according to German, French, and American standards; the results differed with the norm or standard considered. The differences may be slight for loose-textured materials, but they are of great importance in the case of a material with a dense texture, *i.e.*, vitrified material. Preliminary immersion was found useless, even harmful, as it hinders the results desired. Norms and standards rarely give absolute total impregnation. M.V.C.

**Practical clayworking. XX (conclusion).** ANON. *Brit. Clayworker*, **44** [517] 40–41 (1935).—It is proposed to show how the works' cost of manufacture is affected by the most modern labor- and fuel-saving equipment. Costs of wire-cut and semidry methods of brick manufacture are dealt with. For Part XIX see *Ceram. Abs.*, **14** [3] 79 (1935). R.A.H.

**Production and use of paving brick.** G. F. SCHLESINGER. *Can. Engr.*, **68** [23] 9–13 (1935).—After a comparison of old and new methods of brick paving, S. shows that the modern design calls for a thinner brick course. The most recent developments include (1) vertical-fiber lug-type of paving brick, (2) surface-removal method of filler application, and (3) de-airing process of paving brick manufacture. Illustrated. E.J.V.

**Reinforced brick masonry lintels.** J. F. NICHOLL. *Brick Clay Rec.*, **86** [5] 160–64 (1935).—Details of the designs and construction of reinforced brick masonry lintels of three types, running bond, soldier, and rowlock, are presented. Reinforced brick masonry in place of structural steel will save money and lower the costs of the brick house construction as compared to frame houses. Illustrated. E.J.V.

BOOK

**Diatom-Tripoli Brick.** KOSHURNIKOV. All-Union Inst. of Specifications and Standards of Bldg. Ind., Moscow, 1932. 39 pp. Price 2R. The description of the lightweight diatom-tripoli brick includes the definition, output, uses, export, import, raw materials used and method of manufacture, properties, tests, storing, and packing. Two All-Union standards, (1) lightweight clay-tripoli or tripoli brick and (2) common-clay brick, are appended. S. I. PERKAL

PATENTS

**Brick, tile, slabs, etc., for building or decorative purposes.** H. F. HANCHER. Brit. 427,730, May 15, 1935 (Sept. 29, 1933).

**Means for manufacturing brick, tile, building blocks, etc.** J. H. PADDON AND C. G. W. WARD. Brit. 427,734, May 15, 1935 (Oct. 19, 1933).

## Refractories

**Brick mason and the brick.** HENRY D. TYSON. *Blast Fur. Steel Plant*, **23** [6] 408–10 (1935).—T. discusses the changes in shapes, brands, and types of brick for steel plant masonry. He points out reasons why a brick mason should inspect refractories for steel furnaces, and recommends the 9- x $4^1/_2$- x 3-in. brick as the ideal size. Carrying a stock of varied sizes often helps to speed up a repair job as it saves cutting and fitting. The ideal refractory for steel furnaces is still to be developed. E.J.V.

**Brick from tubular kiln sinter magnesite.** P. M. MUSIENKO. *Ogneuporui*, **2** [12] 37–40 (1934).—It has been assumed that magnesite brick can not be produced from sinter magnesite fired in tubular kilns, only those fired in shaft kilns giving satisfactory results. M. demonstrates that, after an appropriate grinding of the sinter magnesite (or working up with pans of the fraction 0 to 1 mm.), good brick can be obtained, but clay must be added to the mass to lend it plasticity during the pressing operation. P.B. & E.S.

**Cracks in blast-furnace refractories.** V. M. STRELETZ. *Ogneuporui*, **2** [12] 17–28 (1934).—The investigation of the causes of cracks in blast-furnace refractories showed that when porous grog with a water-absorption capacity of over 12 to 12.5% is used in the production process, it must be watered before crushing. This eliminates absorption of water from the mass, leading to a lowering of the plasticity of the latter when stored; otherwise, the pressing should take place immediately after the issuance of the mass from the auger machine. P.B. & E.S.

**Development possibilities of special refractories.** FRITZ HARTMANN. *Ber. deut. keram. Ges.*, **16** [1] 36–44 (1935).—A brief discussion is presented of (1) the possibilities of improving refractories from the maker's viewpoint, (2) preparation, forming, and firing of raw materials, (3) fused refractories, (4) coöperation with the users, and (5) works statistics and control. The possibilities of development of chrome ore, dolomite, zircon, silicon carbide, sillimanite, bauxite, corundum, and cast refractories are also taken up. E.J.V.

**Dry-pressed brick plant of the Kuznetzk iron and steel combine.** P. D. GONTCHAR. *Stroitel. Material.*, No. 1, pp. 9–17 (1935). P.B. & E.S.

**Effect of repeated firing on the specific gravity and microstructure of some aluminum-silicate minerals.** F. H. RIDDLE AND A. B. PECK. *Jour. Amer. Ceram. Soc.*, **18** [7] 193–98 (1935).

**Experiences with new types of highly refractory materials in open-hearth furnaces.** A. HEGER, A. SONNTAG, AND M. LEINEWEBER. *Stahl & Eisen*, **55** [10] 265–76 (1935).—Comparisons under actual plant conditions have been made between various types of ordinary silica and magnesite brick and eight new types of brick containing mainly magnesite and (or) chrome ore. Extensive data are presented of the properties of all materials tested. It was found that the furnace construction may be adapted eventually for the use of these new refractories. An outlook for operating open-hearth furnaces using the new materials is given. An extensive discussion is given on experiences with various new materials in plant work. W.M.C.

**Experiences with special types of refractories.** F. W. MORAWA. *Stahl & Eisen*, **55** [8] 201–206 (1935).—M. investigated special types of refractories in open-hearth furnaces, such as magnesite and chrome-ore brick manufactured by various concerns. Data are presented regarding corrosion behavior, length of service, and costs. Such refractories may often be used economically in open-hearth furnaces. W.M.C.

**German crucible graphite.** ERICH BUCHHOLTZ. *Ber. deut. keram. Ges.*, **16** [1] 19–26 (1935).—Amorphous graphite is found in Czechoslovakia, Austria, Mexico, Italy, and Korea, while crystalline graphite is obtained mainly from Ceylon, Germany, Madagascar, and Norway. The crystalline graphites are used for ceramic purposes. Chemical compositions of Bavarian and Madagascar graphites are given and discussed. The development of the German graphite industry is outlined. Illustrated. E.J.V.

**Glasshouse superstructure material.** W. L. FABIANIC. *Jour. Amer. Ceram. Soc.*, **18** [7] 211–19 (1935).

**Kyanite as a high-refractory raw material.** G. L. EFREMOV. *Ogneuporui*, **3**, 135–40 (1935).—An 87% concentrate of kyanite and high sintering clay was fired at over P.C.E. 14. The best composition of the charge was 60% kyanite and 40% clay. A satisfactory product was obtained, but the beginning of deformation under load was at 1425°, and the water absorption, 15%. The firing temperature must therefore be higher than cone 14. Kyanite should be finely ground (0.3 mm.) and the firing of kyanite must be done in kyanite saggers at the temperature of firing of the finished product. Kyanite masses can be used as protective coatings. The clay content in the masses should be lowered. P.B. & E.S.

**Linings for rotary furnaces.** J. DAUTREBANDE. *Rev. mat. constr. trav. pub.*, No. 305, pp. 37–41 (1935).—The causes of the destruction of clinker cement linings of rotary furnaces are dealt with. D. concludes with instructions for the manufacture, placing the blocks, choice of materials, and firing, which will prolong the life period of the blocks. M.V.C.

**Methods of evaluation and technological classification of quartzites.** G. V. KUKOLEV. *Ogneuporui*, **3** [1] 7–16 (1935).—For the technological evaluation and classification of quartzites the following characteristics are of essential value: (1) total chemical composition, (2) chemical composition and quantity of incidental impurities, (3) mechanical properties, (4) porosity, (5) behavior of lump quartzites on firing; extent of regeneration, change of structure, and behavior during the firing of the brick made from the given quartzite. Based on these characteristics, the quality of quartzites of the Ukrainian deposits and of some of the Ural deposits has been evaluated, and data on the above characteristics of these quartzites are shown in several tables. The classification is divided into the following groups: (1) slowly regenerating quartzites: (*a*) those retaining their dense structure after firing,

(*b*) those becoming friable and easily crumbling; (2) quartzites demonstrating a retarded regeneration: (*a*) dense, (*b*) comparatively porous; (3) quartzites with a medium speed of regeneration: (*a*) dense, (*b*) comparatively porous and very porous; (4) quickly regenerating (porous) quartzites. Characteristics of each grade are given. P.B. & E.S.

**Open-hearth furnace design and control.** V. H. Legg. *Jour. Inst. Fuel*, **6** [30] 349–57 (1933).—The importance of regulating the flow of both gas and air to the furnace and the waste gas from the furnace, as a means of speeding up furnace production, economizing in refractories, and saving fuel is stressed. Experiments are described in which the flow of air, gas, and waste gases was measured on a number of furnaces and compared. A new method is described whereby air infiltration through the regenerator walls can be directly measured. One of the chief obstacles to the flow of air and gas is the checker employed in regenerators, and the results of investigations carried out in an experimental regenerator to determine the resistance of various checker settings in common use are given. H.E.S.

**Producing brick from a silica mass by the ramming method.** R. M. Gurvich and S. M. Rozenblit. *Stroitel. Material.*, No. 1, p. 31 (1935). P.B. & E.S.

**Production of electrically fused cast mullite refractories in the U. S. A.** S. I. Perkal. *Ogneuporui*, **3** [1] 53–59 (1935). P.B. & E.S.

**Quartzites partially replaced by sand in silica brick production.** I. S. Smeljansky, V. I. Tokarev, and I. P. Rozhkov. *Ogneuporui*, **3**, 103–109 (1935). P.B. & E.S.

**Red hearts in fire brick and fireclay shapes.** C. M. Dodd and S. R. B. Cooke. *Claycraft*, **8** [8] 324 (1935).—By means of mineragraphy (the study of opaque or semi-opaque minerals in polished sections), the authors have determined the chemical reactions and physical changes within a cored brick. Red coring is the result of improper firing conditions which do not permit the ware to oxidize completely. The large amount of water carried into the kiln in the ware (45 T. to each 100,000 brick not being unusual) requires that a long water-smoking period be held. Unless this period is properly completed, the ware in the bottom of the kiln is subjected to a rapidly rising temperature immediately upon the removal of all the water, and the rate is usually such that oxidation may be only just begun when vitrification begins, after which oxidation is either very slow or completely stopped. M.C.S.

**Refractories in Germany.** A. A. Gusinskiĭ. *Ogneuporui*, **3** [1] 60–64 (1935).—Observations on the uses of refractories (especially of highly refractory materials) made during a tour in Germany are given. Descriptions and chemical analyses of samples of "Radex" (*Ceram. Abs.*, **14** [5] 117 (1935)), "Rubinite," and "Radex E," are given. P.B. & E.S.

**Refractories with an increased grog content produced by the air-ramming method.** I. T. Eremeev and V. M. Streletz. *Ogneuporui*, **3** [1] 41–47 (1935).—The molding of refractories with a high content of grog proved possible. It is most expedient for large simple shapes with a limited quantity of clay binding (15 to 20%). P.B. & E.S.

**Refractory brick with low-fired grog.** S. Glebov. *Ogneuporui*, **3** [1] 25 (1935). P.B. & E.S.

**Refractory brick with low-fired grog.** E. K. Keler and V. P. Zegzhda. *Ogneuporui*, **3** [1] 26–34 (1935).—An investigation undertaken under plant conditions showed the possibility of obtaining satisfactory grog refractories, even of large shapes (for blast furnaces), with grog fired at low temperatures (up to 800 to 850°). Accurate drying and a slow rise of the firing temperature of the brick in the interval 900 to 1300° are essential. The use of low-fired grog results in brick with a higher density and better mechanical properties and with fewer cracks. The efficiency of the method consists in lowering fuel and grinding costs. Slag-resisting refractories could be expediently produced by this method; its use for the production of glass-furnace blocks, stoppers, and other refractories for steel casting should be investigated. P.B. & E.S.

**Repairing a large smelter chimney injured by spalling.** John E. Lanning. *Trans. Amer. Inst. Mining Met. Eng.*, **106**, 282–96 (1933).—L. describes the failure of a large modern brick chimney to such an extent that its safety was vitally impaired, the investigation of its condition, methods of restoring satisfactory strength to the structure, and the installation of an acid-proof lining. The total cost of repair was approximately 40% that of a new acid-proof chimney. A.P.

**Resistance to softening under load at high temperatures.** Seiji Kondo and Shin-ichi Suzuki. *Jour. Soc. Chem. Ind.* [Japan], **38** [4] 129*B* (1935).—The fact that the softening point under load of most ceramic products decreases regularly is explained according to the law of Clasius-Clapayron, and the formula $1 = Ce^{-kp}$, which presents the relation between the softening point, the refractory degree, $C$, the charge, $p$, and a constant, $k$, is discussed. A method of calculating the resistance to softening under load at high temperatures can be introduced here. M.V.C.

**Shokshino quartzites.** I. S. Smeljansky. *Ogneuporui*, **2** [12] 8–14 (1934).—The possibility of producing silica brick from quartzites of the Shokshino deposits (Carelia) is discussed. The chemical composition of these quartzites is as follows: $SiO_2$ 96.88 to 97.21, $Al_2O_3$ 1.00 to 1.41, $Fe_2O_3$ 0.40 to 0.83, CaO 0.04 to 0.32, MgO traces to 0.17, $K_2O$ 0.32 to 0.38, ignition loss 0.34 to 0.44. Investigations have been undertaken by the Leningrad Institute of Chemical Technology and the Ukrainian Refractories Institute. The positive results of the former are being criticized. P.B. & E.S.

**Silica brick from Ocheretino quartzites.** I. S. Smeljansky, V. I. Tokarev, and I. P. Rozhkov. *Ogneuporui*, **3** [1] 17–24 (1935); see also "Quartzites—" *Ceram. Abs.*, **14** [4] 100 (1935). P.B. & E.S.

**Sulfite-cellulose lye substituted for molasses.** P. P. Budnikoff and N. S. Kassian. *Ogneuporui*, **3**, 98–100 (1935).—A plant investigation of the use of concentrated sulfite lye demonstrated the possibility of obtaining satisfactory silica brick, the mechanical strength obtained being even greater than usual. The specific weight fell. Lye should be used in a proportion of 0.5%; when introducing sand to the charge it can be raised to 0.8 to 1%. P.B. & E.S.

**Sulfite-cellulose lye instead of molasses.** I. S. Smel-

JANSKY. *Ogneuporui*, 3, 100–102 (1935).—Another investigation demonstrated that lye used even in addition to 2% of lime in a proportion of 0.125 to 0.25% gives quite satisfactory results, raising the strength of brick pressed on Buckau presses before firing. The mineralogical structure of the brick is in no way influenced. P.B. & E.S.

**Twelve years' research on the thermal conductivity of refractory products at high temperatures.** A. GRANGER. *Céram., Verrerie, Émail.*, 2 [8] 341–44; [9] 381–86 (1934).—Thermal expansion is measured by the use of a calorimeter which measures the quantity of heat flowing through the body, by thermocouples which measure the temperature rise, or by measuring the linear diffusion. Results are as follows: (1) With silica and clay the conductivity increases with the temperature. (2) With magnesite the conductivity does not increase. (3) The conductivity of clay and silica are similar, magnesite being four or five times as great. (4) The conductivity of pure silicon carbide is constant between 650 and 1350°; it increases with the temperature in bonded silicon carbide. (5) The conductivity of refractory products decreases with an increase in clay. (6) The conductivity of clay is approximately inversely proportional to the porosity. (7) At a given temperature the conductivity of silicon carbide increases with the quantity of heat transmitted; clay is independent of the heat transmitted. (8) The fusion temperature tends to raise the conductivity. Several figures for different refractories are given.

M.H.B.

BIBLIOGRAPHY

**Refractory References** (Feuerfest Kartothek). Edited by L. LITINSKY. 25,000 cards (size $4^1/_4$ x $5^7/_8$ inches). L. Litinsky, Leipzig, 1935. Price 1800 M., postage extra. This bibliography includes references to all refractory literature of the world published from 1920 to 1934, including articles, books, patents, publications of firms, data, etc. A cross-index of more than 3000 words is provided. These cards represent a work of a magnitude and completeness never before offered in this field. In addition to the original source each card notes the places in which the article in question has been republished, when this is the case. Litinsky, who also issues the *Referatkartei der Silikatliteratur* (See *Bull. Amer. Ceram. Soc.*, p. 174 (June, 1934)), is well known for his publications in this field.

BOOKS AND BULLETINS

**Blast-furnace linings. I. Replies to a questionnaire circulated to iron manufacturers.** A. T. GREEN. *Iron and Steel Inst. Special Rept.*, No. 7, 29 pp. (1934).—G. gives a detailed discussion of the replies to the following questionnaire:

*Section A: Refractory materials used*

(1) From what district or firms do you draw your supplies of brick for blast-furnace linings?
(2) Do you specify different materials for the different zones of the furnace? Give details.
(3) What are the analyses of the brick you use?
(4) Do you specify a maximum "iron content" in the lining material? State this maximum and why you specify this figure.
(5) Do you specify any particular conditions of manufacture, such as grading, machine-pressing, hand-molding, etc.? Give details.
(6) Have you found any differences in the durability of linings consequent on any particular process of manufacture? Give details.
(7) Do you specify any particular laboratory testing for your refractory lining such as the determination of (*a*) porosity, (*b*) refractoriness, (*c*) refractoriness under load, (*d*) crushing strength, (*e*) transverse strength, (*f*) after-contraction or expansion at 1350° or 1410°, etc.? Give details.
(8) Do you line your furnaces with large blocks? State maximum thickness.
(9) Do you line your furnace with small brick? State size and your experience of their use.
(10) Do you adopt measures to protect refractories from the influences of weather during storage and prior to relining?
(11) Do you specify characteristics of the jointing cement used?

*Section B*

(1) Have you any phenomenal instances of failure of blast-furnace linings on which you care to give particulars and your own opinions to the Committee?
(2) Do you believe in steel or cast-iron protection for brick in the top of the furnace? State type and give sketch.
(3) What is your opinion of the effect of the bell diameter on linings and what is your practice?
(4) Have you any opinions on the character of the furnace lines with regard to the wear of the linings?
(5) What is your experience of mechanical *vs.* hand charging in its effects on blast-furnace linings?
(6) Do you use bosh tuyères? Have you any information as to deleterious effects of such tuyères upon the lining?
(7) Have you any experience with stack cooling? Describe the type and state the effect of this cooling on the life of the lining.
(8) Are you able to screen the breeze from your coke, and what is your experience of its effect on the sizing of materials on linings?
(9) Have you any experience on the effect of the sizing of materials on linings?
(10) Do you consider that varying the grade of the iron produced by the furnace has any deleterious influence on the linings?
(11) Have you any experience on the addition of (*a*) steel turnings, (*b*) scrap metal, (*c*) basic slag to the charge? Do you consider that this addition has a scouring action on the lining?
(12) The Committee would be pleased to receive information concerning the durability of furnace linings not contained in these questions, *e.g.*, the use of carbon blocks.

*Section C*

(1) Do you take measurements of your furnace linings after blowing out? Have you available any such drawings relating to your last furnace relined?
(2) Can you let the Committee have drawings showing the principal features and dimensions of this furnace at the commencement of the campaign?
(3) Could you give the history of this campaign? In this answer it is desirable to include the following data: (*a*) periods of working (dates, showing shut-downs, etc.), (*b*) period in blast: (*c*) (1) total make of all grades of iron, giving make of each grade and (2) make per week, (*d*) total burden passing through the furnace, (*e*) coke consumption per ton of pig iron, (*f*) constitution and character, including size and mechanical condition, of (1) ores or other iron-bearing additions, (2) coke, (3) limestone, (*g*) proportion of ores, limestone, and coke in the burden, (*h*) analysis and grade of iron or irons made, (*i*) data concerning variation in the grade of irons made

by this furnace during the campaign, (*j*) blast pressure at engine house, (*k*) blast temperature either at stoves or at hot blast main, (*l*) temperature at top of furnace, and (*m*) a description of any abnormal circumstances and interruptions of working, such as scaffolding, hanging, explosions, break-outs, etc., which have occurred during this campaign.

(4) What is the alkali content of your charge?
(5) What other ingredients are in your charge which you consider may have a deleterious effect on your linings and to which you would care to draw the Committee's special attention?
(6) What is the position and number of your gas outlets?
(7) What is the position of the tuyères relative to the tapping hole?
(8) Can you give the Committee any other apposite information concerning this campaign?

**II. Properties of the fireclay products used for blast-furnace linings.** A. T. Green, W. Hugill, F. H. Clews, and H. Ellerton. *Ibid.*, 25 pp.—Samples of eleven unused representative materials for blast-furnace linings were tested for texture, chemical composition, refractoriness, refractoriness under load, porosity, after-contraction or expansion at 1350°C and 1400°C, permeability to gases, and the disintegrating action of CO. The results are reported in detail. J.B.A.

**Casting ladles.** V. A. Yakimov and B. M. Pevzner. State Sci.-Tech. Pub. House of Ferrous and Nonferrous Metallurgy, Leningrad, Moscow, and Sverdlovsk, 1935. 88 pp., 84 illustrations. Price 1R 20k. The book on casting ladles deals with their construction, description of the usual failures, lining and drying, and their service and calculations. S. I. Perkal

**Specifications of clays for the glass industry.** G. Yu. Zhukovskiĭ. State Sci. Research Inst. of Glass: State Pub. House of Light Ind., Moscow and Leningrad, 1935. 48 pp. Price 75 kopeks. The literature on specifications is reviewed. Z.'s critical notes on specifications for clays used in the glass industry are presented. Specifications developed by Z. for compounding clays for the same purpose are outlined. S. I. Perkal

PATENTS

**Fire wall.** Michael Liptak. U. S. 2,002,820, May 28, 1935 (Jan. 10, 1931).

**Method of making crystalline alumina and composition containing it.** R. R. Ridgway (Norton Co.). U. S. 2,003,867, June 4, 1935 (Sept. 22, 1933).—The process of removing traces of partially or difficultly reducible metal oxide impurities from a melt of alumina formed by the reduction of bauxite with carbonaceous reducing agents comprises the steps of incorporating in the furnace charge an easily reducible metal sulfide and an alkaline metal oxide and adjusting the sulfur content of the mixture so that after fusion and cooling the metal oxide impurities will be separated into a water-soluble or hydrolyzable matrix, the sulfide sulfur content of which is not over 2% by weight of the total melt. An article of manufacture comprises a solidified ingot containing upward of 85% pure crystalline alumina as discrete crystals in commercial grain sizes loosely cemented with a disintegratable matrix containing the sulfide of an alkaline metal associated with compounds of titanium and zirconium; the matrix contains from 25 to 40% by weight of aluminum sulfide, 25 to 70% of alkaline metal sulfide, and 0 to 35% stable sulfides. The total sulfide content is not over 3% by weight of the whole ingot.

**Method of making refractory products, etc.** Charles McMullen (Carborundum Co.). U. S. 2,004,378, June 11, 1935 (Dec. 18, 1933).—In the method of forming articles of nonmetallic refractory material, the steps comprise casting the material in molten form into a mold and against a core of metal of high thermal conductivity having a melting point below that of the cast article, transferring heat from the casting to the core whereby the face of the casting in contact with the core becomes solidified and the core in turn then becomes molten, and flowing the core from within the cast article.

**Process of making silicon carbide articles and raw batch therefor.** R. C. Benner and H. N. Baumann, Jr. (Carborundum Co.). U. S. 2,004,595, June 11, 1935 (Aug. 26, 1932).—In the process of making silicon carbide refractory articles the steps comprise admixing with silicon carbide grain a carbonaceous temporary binder and a vitrifiable binder of that class of mixtures of fluxing and refractory materials, each of which is characterized when present in such an admixture by initial softening of a portion only thereof at but not substantially below a temperature approximating that at which rapid oxidation of silicon carbide begins, in which softened portion the more refractory portion dissolves in increasing amounts progressively over a range of at least 400°C as the temperature is raised above the initial softening point, forming the mixture, heating the formed mixture for a time sufficient to burn out the temporary binder at a temperature below that at which rapid oxidation of silicon carbide begins, and thereafter raising the temperature to a point sufficient to cause the bond to flow enough to protect the silicon carbide from oxidation which would otherwise take place.

**Refractories.** A. H. Stevens (Ferro Engineering Co.). Brit. 428,228, May 22, 1935 (Nov. 9, 1933).

**Silicon carbide refractory.** R. C. Benner and H. N. Baumann, Jr. (Carborundum Co.). U. S. 2,004,594, June 11, 1935 (Jan. 28, 1934). A refractory article comprises silicon carbide and a bond containing calcium fluoride.

## Terra Cotta

**Chemical stoneware in the finishing industries.** Percy C. Kingsbury. *Metal Cleaning & Finishing*, **7** [5] 239–42 (1935).—The principles governing the installation and use of chemical stoneware for metal cleaning and finishing processes are described. E.J.V.

**Colored tinless enamels for tile for inner linings.** S. Filippov. *Stroitel. Material.*, No. 10, pp. 54–56 (1934).—F. describes three compositions used at a Moscow plant. P.B. & E.S.

**Manufacture of statues, groups, and figures in ceramics.** Alix Cornille. *Céram., Verrerie, Émail.*, **1** [12] 395–97 (1933); **2** [1] 13–17; [2] 63–66; [3] 115–20; [5] 203–208;

[6] 258–60; [8] 347–50; [10] 444–46 (1934); **3** [1] 17–20 (1935).—C. gives in detail the processes used in making statuary, dwelling particularly on designing and assembling the molds. M.H.B.

**Production of large glazed terra cotta slabs.** MAURICE BARRETT. *Brit. Clayworker*, **44** [517] 44–45 (1935).—The future of the terra cotta industry lies in the manufacture of large thin-glazed slabs free from cracks and other defects. The popular unit at present measures 24 x 12 x 1 in., but slabs 36 x 18 x 1 in. have been produced. After many different methods of manufacture were tried the process of expressing hollow triangular units through a vertical die was considered to be the most satisfactory. R.A.H.

**Stoneware tile bodies.** F. CHALAMEL. *Céram., Verrerie, Émail.*, **2** [10] 437–40; [11] 483–88 (1934).—C. discusses the grinding of raw materials and the mixing and molding of stoneware tile. Several practical suggestions are given. M.H.B.

PATENTS

**Lightweight article and method of manufacturing.** E. R. POWELL (Johns-Manville Corp.). U. S. 2,003,309, June 4, 1935 (Dec. 13, 1932).—In making an article comprising ceramically bonded fibers, the method includes forming an aqueous mixture of heat-resistant fibers with a binder containg clay, shaping the mixture, removing water from it, and then firing the product at a temperature adapted to cause vitrification of the binder but below the temperature of slagging of the fibers.

**Lightweight ceramic article and method of making.** BAILEY TOWNSHEND (Johns-Manville Corp.). U. S. 2,003,319, June 4, 1935 (Dec. 13, 1932).—In making a ceramic product provided with voids partly filled with fibrous material, the method comprises treating heat-resistant fibers with a water-repellent material to render the fibers water-resistant, making a plastic mixture of the treated fibers, clay, and water, and shaping, drying, and firing the mixture to develop a ceramic bond with preservation of the shape of approximately the original fibers.

**Method of producing sound-absorbing material.** CHARLES BIRCHY (Samuel D. Hewlett). U. S. 2,004,686, June 11, 1935 (April 21, 1933).

## Whiteware

**China trade and London "chinamen."** AUBREY J. TOPPIN. *Trans. English Ceram. Circle*, No. 3, pp. 37–56 (1935).—Merchants dealing mainly in china and earthenware in London during the middle of the 18th Century were called "chinamen" to distinguish them from the actual manufacturers of ware. These merchants and their ceramic trade up to about 1780 are discussed. Illustrated. H.S.

**Decoration of porcelain.** P. DE GROOTE. *Céram., Verrerie, Émail.*, **2** [12] 515–20 (1934).—One of the defects of porcelain decoration by decalcomania is "gripping." To prevent this defect (1) the varnish used must be closely watched; (2) the decoration should not be heated too rapidly during the preheating period; and (3) the decoration should be dry before placing in the furnace. M.H.B.

**Effect of bentonite additions to raw kaolin.** HANS LEHMANN. *Ber. deut. keram. Ges.*, **16** [1] 31–36 (1935).—Reference is made to the work of Endell and Vageler (*Ceram. Abs.*, 12 [5] 206 (1933)). Experiments were carried out on different kaolins and an earthenware clay, with and without additions of Co-bentonite, and determinations were made of the drying and firing shrinkages, dry strength, plasticity (Pfefferkorn method), fired color, and water absorption. The dry strength of raw kaolins was greatly increased by the addition of increasing amounts of bentonite but the effect was much less marked on mixtures of kaolins and clays. The plasticity of the raw kaolins was increased up to a 6% addition of bentonite, whereas that of the kaolin-clay mixture was increased beyond the 6% addition. The results indicate that the use of bentonite deserves further investigation. E.J.V.

**Effect of furnace atmosphere and vacuum upon the vitrification of a high mullite porcelain.** A. M. HOSSENLOPP AND R. RUSSELL, JR. *Jour. Amer. Ceram. Soc.*, **18** [7] 204–205 (1935).

**Effect of zinc oxide on kaolin at different temperatures.** R. RIEKE AND W. PASCH. *Ber. deut. keram. Ges.*, **16** [2] 49–62 (1935).—The reactions between zinc oxide and clay-containing bodies were investigated. Various mixtures of zinc oxide and silica were heated from 800 to 1250°; silicate formation began at about 1000°, the quantity of zinc oxide entering into the reaction being greater, the lower the zinc oxide content of the mixture. Only the orthosilicate, $2ZnO \cdot SiO_2$, was found. In mixtures of well-washed kaolin and zinc oxide, the reaction begins at about 900° with a simultaneous formation of zinc orthosilicate and zinc aluminate (zinc spinel); the tendency, especially at high temperatures, is toward the greater spinel formation, so that nearly all of the alumina is transformed into spinel. As both the aluminate and the silica in the form of cristobalite are less fusible at high temperatures than the zinc silicate, it may be assumed that high alumina bodies in contact with zinc oxide will be more refractory than high silica bodies. Cone melting-point determinations of kaolin-zinc oxide mixtures with increasing zinc oxide content indicated a softening minimum at about 1320° and the ratio $2.4ZnO : 1Al_2O_3 : 2SiO_2$ with a 47% zinc oxide content. Thermal expansion measurements on kaolin-zinc oxide mixtures fired at different temperatures and with varying zinc oxide content pointed to the existence of a zinc disilicate or zinc aluminosilicate since, at firing temperatures up to 1150°, no free silica in the form of cristobalite was found, which would have been the case if only zinc orthosilicate had been formed. Cristobalite in considerable amounts was found only in bodies fired above 1150°, indicating that the above assumed compound is not stable at high temperatures. E.J.V.

**Expansion behavior of earthenware glazes.** HANS LEHMANN AND MARIA-THESIA SCHULZE. *Ber. deut. keram. Ges.*, **16** [1] 1–19 (1935).—The expansion behavior of an earthenware glaze and of some of its binary and ternary systems was investigated with the object of relating the results to the problem of crazing. Mixtures of the binary and ternary systems occurring in the commercial

glaze were prepared, *e.g.*, lead–silica, boric acid–silica, borax–silica, and lead–boric acid–silica. The coefficient of expansion of the glazes and glasses was determined with a modified form of the Pulfrich apparatus. The expansion coefficient of the glaze was determined in several series of experiments and was found to be greatly influenced by the temperature and the number of firings. While the test pieces showed a permanent expansion, which was determined for an earthenware glaze by systematic firing tests, no permanent linear expansion could be found for the lead-silica glass. The results indicate that determinations of the coefficient of expansion of glaze and body do not provide a satisfactory means of solving the problem of crazing. The problem might better be attacked by a study of "delayed crazing," as has been done in America, and important data might be found from research on the permanent linear expansion of bodies and glazes.

E.J.V.

**Guarantee tests for porcelain insulators.** W. Weicker. *Arch. Tech. Mess.*, **3**, 165–66*T* (1933).—Requirements for the electrical, mechanical, and thermal behavior of porcelain insulators and tests for density and porosity, according to the particular use of the insulator as prescribed in the German standard specifications, are described. 21 references. M.H.

**High specific gravity slips.** P. W. Dager. *Jour. Amer. Ceram. Soc.*, **18** [7] 201–203 (1935).

**Multiple casting of cup handles, ornaments, and other small pieces in porcelain, faience, and stoneware.** P. Renault. *Céram., Verrerie, Émail.*, **2** [4] 165–69; [5] 209–13; [6] 253–57; [7] 295–301 (1934).—R. describes in detail the processes used in designing and making multiple molds and methods of casting cup handles and other small pieces in these molds. Illustrated. M.H.B.

**Proper slip preparation aids in control of pottery bodies.** C. P. Stotler. *Ceram. Ind.*, **24** [6] 357–58 (1935).—Proper slip preparation depends largely on thorough blunging. As ball clays are hardest to blunge, they should be shredded. The blungers should be run until the ball clay is thoroughly blunged. A rotary sifter is superior to the reciprocating type as it takes less power to operate and is cheaper to maintain. Slip temperature, pumping pressure, and mixing time are important in obtaining properly conditioned bodies. The body must be aged properly. Careful handling of molds is essential for the best results in casting. E.J.V.

**Soaprock licenses.** E. Morton Nance. *Trans. English Ceram. Circle*, No. 3, pp. 73–84 (1935).—Cornish soaprock, a natural mixture of steatite and china clay, was mined for use in 18th Century porcelain. Early mining licenses are given. Illustrated. H.S.

**Streak formation in ceramic casting slips.** K. Pfefferkorn. *Ber. deut. keram. Ges.*, **16** [1] 26–31 (1935); see *Ceram. Abs.*, **13** [11] 296 (1934). E.J.V.

**Substitution of whiting by magnesite in common faience and coarse pottery bodies.** W. Steger. *Ber. deut. keram. Ges.*, **16** [2] 62–70 (1935).—When magnesite is substituted for whiting in bodies composed of a low-melting clay and whiting or of a low-melting clay, sand, and whiting, the following changes in properties take place after firing to cone 07*a:* (1) firing shrinkages, especially in bodies with high MgO content, are considerably smaller; (2) water absorption of magnesite bodies is greater; (3) thermal expansions of magnesite bodies in a given temperature range are always smaller than those of whiting bodies; (4) due to the high content of free MgO, magnesite bodies are more easily attacked by water; and (5) the modulus of rupture of a low-fusing clay is reduced by the addition of magnesite and increased by whiting. In general, no advantage was found in substitution of magnesite for whiting. E.J.V.

**Talc compositions.** F. J. Fallon. *Jour. Amer. Ceram. Soc.*, **18** [7] 199–201 (1935).

**Trend of the pottery industry.** A. E. Hewitt. *Pottery Gas.*, **60** [696] 769–71 (1935).—H. points out two events which have caused interest in the pottery industry during 1934: (*a*) stimulation of interest in the improvement of industrial art and design and (*b*) greater use of mechanical and electrical appliances and keener application of scientific knowledge and research. He discusses sagger making, water softeners, casting slip and flint, sliphouse developments, de-airing, mechanical handling, drying, firing, gas-fired ovens and kilns, electric kilns, elimination of smoke, bedding flint, and the human element as connected with the pottery industry. E.J.V.

PATENT

**Apparatus for molding water-closet rims.** J. M. Trahen. U. S. 2,002,873, May 28, 1935 (Feb. 12, 1934).

## Equipment and Apparatus

**Adiabatic air drying of hygroscopic solids.** D. W. McCready and W. L. McCabe. *Trans. Amer. Inst. Chem. Engrs.*, **29**, 131–61 (1933).—Experimental data on adiabatic air drying of slabs of paper pulp and asbestos are given. Existing conceptions of the mechanism of drying are modified to explain the experimental results. The effects on the mechanism and rate of drying of porosity, specimen thickness, and density, and the temperature, humidity, and velocity of the air stream are evaluated.

A.P.

**Air conditioning for enclosed machines.** H. Neale. *Elec. Rev.*, **116** [2990] 374–75 (1935).—Inlet air conditioning for enclosed electrical machinery in dusty or corrosive atmospheres and for large high-speed machines is described. Filtering devices may be employed for the first two cases while the third requires a closed circuit cooling system. Dry and wet filters are described. Closed circuit cooling requires a heat extraction unit in the form of a nest of tubes through which a cooling medium flows. Hot air from the machine passes over the tubes; it is cooled and returned to the machine. Such a circuit is described in detail with calculations. Illustrated.

J.L.G.

**Alloy orifices in refractory dies.** H. K. Richardson and F. A. Newcombe. *Glass Ind.*, **16** [6] 176–77 (1935).—A refractory die with an alloy lining has made it possible to obtain a uniform flow of glass in filling lamp bases. The alloy lining increases the life of the die 190 times and the

production from 7 to 15%. The alloy of 90% platinum and 10% rhodium was found best in resisting the abrasive action of the hot flowing glass, and a lining of this alloy is inserted into an Alundum refractory support. Illustrated. E.J.V.

**Apparatus for measuring transverse expansion, particularly in notches.** A. KRISCH. *Messtechnik*, **10** [10] 181–84 (1934).—The apparatus is suitable for determining Poisson's constant and the transverse expansion of round and flat specimens with sharp notches or indentations; it is easily handled and does not absorb any part of the expansion. The reading is made by a mirror and a long light lever. The application is described. A movement of about 1/1,000,000 cm. can be determined. M.H.

**Chamber drier with direct warming.** I. A. SURNIN. *Stroitel. Material.*, No. 1, pp. 23–25 (1935). P.B. & E.S.

**Commercial drier to control drying as efficiently as laboratory model.** ERNEST W. KNAPP. *Brick Clay Rec.*, **86** [5] 169–70 (1935).—K. describes in detail an automatic pallet-type drier, claimed to be adjustable to any drying condition. It is of compact construction and operates rapidly. Temperature control is provided for, and highly efficient operation is obtained. E.J.V.

**Determination of true creep velocity by the W. Rohn creep-limit apparatus.** H. KRAINER. *Messtechnik*, **11** [3] 43–48 (1935).—The difficulties of exact determination of creep strength and creep velocity and certain inaccuracies are pointed out when the Rohn apparatus is used in a measurement in which the mechanical expansion of a specimen by a weight is counteracted by thermal changes of length. The calculation of the true creep velocity from the readings of this apparatus is explained. M.H.

**Development of hydrogen porosimeter.** C. J. COBERLY AND A. B. STEVENS. *Trans. Amer. Inst. Mining Met. Engrs.*, **103**, 261–70 (1933).—A new apparatus determines the volume of the grains and the sealed pore space from the pressure relations established in the instrument by the introduction of a known quantity of hydrogen. It consists of an upper chamber for measuring the gas, a lower chamber for holding the sample, a pressure gage, a tank of hydrogen, and the necessary connections. The advantages of hydrogen are (1) slighter deviation from the gas laws, (2) ready penetration, and (3) lesser absorption than most gases by the solids and liquids with which it may come in contact. A.P.

**Electric thickness meter.** ALBRECHT. *Messtechnik*, **10** [9] 165–69 (1934).—Determination of the diameter of fine wires or threads or of wall thicknesses, which are otherwise inaccessible, by electric or electromagnetic devices is described in detail. M.H.

**German testing machines for building materials.** GEORG SAENGER. *Eng. Progress*, **16** [4] 89–95 (1935).—A number of hydraulic testing machines are described. These machines are designed for compression, tension, and bending and buckling tests on columns, blocks, and bars. Methods and devices for checking the accuracy of the test machines are considered. 15 photographs. J.L.G.

**High-voltage testing laboratory.** PORCELAINE FABRIKEN NORDEN. *Elec. Rev.*, **116** [2996] 593 (1935).—A new high-voltage testing laboratory at Copenhagen Valby is briefly described. A single large test hall contains equipment for (1) 50-cycle a.c. tests up to 750 kv. effective power or 1500 kv. to earth, (2) shocks up to 2250 kv. to earth with a spark gap formed of spheres approximately 5 ft. in diameter, (3) high-frequency installations for pressures up to 1000 kv. to earth. A rolling crane for handling the equipment under test is provided. A balcony at one side provides a safe place from which to watch tests. The building is 118 ft. long, 65 ft. wide, and 69 ft. high. Illustrated. J.L.G.

**Hollinger respirator.** W. A. JONES AND D. A. MACLEOD. *Eng. Mining Jour.*, **136** [3] 115 (1935).—A respirator whose resistance to breathing is so low that men wearing it may readily walk about or perform a moderate amount of work with no discomfort is described. The filter consists of a flat bag, 10.5 x 11 x 1 in., each side of which consists of two layers of medicinal absorbent cotton between three layers of thin penrant felt. An 8-mesh wire frame inside the bag keeps it from collapsing. The assembly is covered by a canvas cover perforated with $^{3}/_{8}$-in. holes fitted with metal eyelets. Dust counts on air pulled in (by a wearer inhaling), when the mask is worn in the highest concentrations of dust encountered, showed not more than 300 particles less than 5 microns in diameter per cubic centimeter of air. Illustrated. J.L.G.

**Impact strength tester.** BURROUGHS MOORE. *Jour. Sci. Instruments*, **12** [4] 108–11 (1935).—The portable outfit described employs a cylindrical steel weight dropping between three stainless steel guide wires. A short rod from the weight is gripped in the jaws of a chuck which can be raised by means of a cord and pulley arrangement. The weight is released at the desired height by turning the chuck. The device illustrated provides for a maximum vertical drop of 23 in. on a test piece, which is a $^{1}/_{2}$-in. cube. The weight of the load should be adjusted so that a fall of not less than 10 in. should break the test piece. Under such conditions results reproducible with less than 0.5% variation were secured. Impact stress is calculated from the formula, $f = \sqrt{(2EWH)/V}$, where $E$ = Young's modulus, $W$ = weight, $H$ = distance the weight falls, and $V$ = volume of specimen in units corresponding to those in which $f$ is to be measured. This value in pounds per square inch averaged 12,093 for six cubes of fused quartz. Illustrated. J.L.G.

**Instrument for measuring the viscosity of milled enamel.** O. HOMMEL CO. *Ceram. Ind.*, **24** [6] 379 (1935).—A brass pipet, using various size nozzles and permitting the accurate determination of both the specific gravity and the viscosity of porcelain enamel slips, is described. Illustrated. E.J.V.

**Lubricating glass machinery.** ALLEN F. BREWER. *Lubrication*, April, 1935; reprinted in *Ceram. Ind.*, **24** [6] 350–51 (1935).—In lubricating the vacuum-type bottle machine, a relatively light-bodied straight mineral oil, low in Conradson carbon residue content, is most suitable. The guide bearing is grease-lubricated with a medium-bodied cup grease or fiber-type grease, while the bath-lubricated reduction gears require a straight mineral gear lubricant of about 1000 seconds Saybolt viscosity at 210°F. Similar suggestions are presented for the lubrication of window-glass machinery, plate-glass equipment, polishing and grinding equipment, and pressing machinery. Illustrated. E.J.V.

**Pottery plant on a conveyer.** WALTER H. EMERSON. *Ceram. Ind.*, **24** [6] 342–47 (1935).—Plant No. 5, Homer Laughlin China Co., at Newell, W. Va., has been designed so that the worker remains stationary. The process of jiggering flat ware has been laid around a 1550-ft. monorail conveyer, of which 1200 ft. comprise a drier. With the exception of cups, no boards of ware are carried. The equipment and structural features are described. Illustrated. E.J.V.

**Precision optical pyrometer.** M. MILFORD, R. J. BRACEY, F. A. CUNNOLD, AND A. C. EGERTON. *Jour. Sci. Instruments*, **12** [3] 80–84 (1935).—A disappearing filament-type pyrometer rigidly constructed for precision work is described in detail. Alternative magnifications of five and twenty times are provided. Special interchangeable monochromatic filters in red and green are used. An arrangement of four absorption screens set in two rotating disks enabled the authors to read temperatures up to and above 5000°K. The object sighted on must be at least 0.2 mm. in diameter for good disappearance. By measuring current to 0.01%, temperatures can be measured to an accuracy of 1 part in 3000 at the gold point (1063°C). Illustrated. J.L.G.

**Small X-ray apparatus for crystal-structure determinations.** W. E. SCHMID. *Z. tech. Physik*, **16** [4] 115–19 (1935). W.M.C.

**Stirl electric screen.** MASCHINENFABRIK FRANZ STIRL. *Eng. Progress*, **16** [2] 52 (1935).—A vertical electric motor built into a suspension frame imparts a continuous uniform vibration to the frame by means of an eccentric. The screen is supported at the lower end of the frame. Models to take screens ranging from 6 to 40 in. in diameter can be supplied. Screens can be readily changed or they can be used nested to secure different grades at one operation. On the larger machines the intensity of oscillation can be controlled. Illustrated. J.L.G.

**Stroboscope and high-speed motion picture camera as research instruments.** H. E. EDGERTON AND K. J. GERMESHAUSEN. *Trans. Amer. Inst. Chem. Engrs.*, **30**, 420–38 (1934).—The stroboscope and stroboscopic-light, high-speed motion picture camera are of especial use in studying rapidly moving objects. Applied to such phenomena as the instantaneous rupture of brittle materials, the photographs should bring out facts about the rupturing process and permit utilization of brittle ceramic materials to get maximum resistance to rupture. A.P.

**Super-hard alloys in plant machinery.** S. GLEBOV. *Ogneuporui*, **3** [1] 72 (1935).—The use of parts with super-hard alloys welded on in the plant machinery (auger machine cutters, pinions of crushers, jaws of Blake crushers, etc.) proved to be very efficient, giving an economy of nearly 75% on parts that have to be replaced often. P.B. & E.S.

**Vacuum for best de-airing results.** THOMAS B. MCAVOY, JR. *Brick Clay Rec.*, **86** [5] 165–66 (1935).—Results obtained in tests on clays using different degrees of vacuum from 1 to 29 in., with three types of dies, are given. The results change with change in type of clay, sizing of the material, and machine speed. Changes in the machine used to obtain the desired results are cited. E.J.V.

**Viscosity measurements at high temperatures by means of free falling spheres.** WILLI M. COHN. *Ann. Physik*, **21** [8] 761–82 (1935).—A method was developed for measuring viscosities of molten silicates in the range from 900 to 1400°C. Spheres made of platinum-rhodium are used, moving freely through the melt which is kept at a constant temperature. Two short platinum coils are wound around the crucible with the melt, the coils being parts of an oscillating system. Changes in the output of a short-wave receiver make it possible to determine the rate of fall of the spheres in the melt, the distance between the coils being known exactly. The viscosity of the melt is computed from the rate of fall of the spheres. The data obtained are reproducible within ±1.5%. Very small changes in the composition of the glasses could be detected readily. Viscosity data of six glasses of widely varying composition are presented. Comparison of these data with data obtained for the same glasses by the method of rotating cylinders carried out at the Bureau of Standards shows a good agreement of the results. The use of the new method for standardizing purposes is emphasized. See also "Viscosity—," *Ceram. Abs.*, **14** [6] 152 (1935). W.M.C.

## Kilns, Furnaces, Fuels, and Combustion

**Action of heat on the principal materials in ceramic bodies, alone or mixed.** A. GRANGER. *Ceram., Verrerie, Émail.*, **2** [10] 429–32; [11] 477–80 (1934).—G. examined silica, alumina, clay, feldspar, mica, and lime as to their fusion and transformation points. The effect of various combinations of these on one another is discussed. M.H.B.

**Basic requirements of the firing process.** J. A. DOYLE. *Bull. Amer. Ceram. Soc.*, **14** [6] 189–93 (1935).

**Calculation of open-hearth furnace regenerators.** HERBERT SOUTHERN. *Jour. Inst. Fuel*, **6** [30] 369–80 (1933).—The design of regenerators has been seriously handicapped by the lack of specific data upon the processes of thermal interchange within the regenerative systems. S. reviews the work of the German Heat Economy Bureau and its associated investigators, Rummel, Schack, Schumacher, Kistner, Trinius, and Kofler. To make the work of more practical value the units have been expressed in British units. S. believes that the work confirms the applicability of the theory of gaseous radiation to the design of regenerators, indicates the effect of the velocity and thickness of the heating and cooling streams on the transmission of heat by convection, and shows the influence of the arrangement and thickness of the brick on the processes of thermal interchange. H.E.S.

**Color pyrometry.** GUSTAV HAASE. *Arch. Tech. Mess.*, **3**, 133–34*T* (1933).—The temperature of a glowing body can be determined by measuring the color temperature which is defined as that temperature of a black body at which the glowing body appears to the eye in the same color as the black body. The various methods of determining color temperature and the representation in the Maxwell-Helmholtz color triangle are explained. An objective method with only one photocell in connection

with red and green filters and a cross-coil galvanometer is described. See also "Color—," *Ceram. Abs.*, **13** [9] 238 (1934). M.H.

**Combustibles and combustion.** É. DE LA FOLLYE DE JOUX. *Rev. mat. constr. trav. pub.*, No. 306, pp. 77–80 (1935).—The use of salt in small quantities (1/1000 of the weight of the fuel) in the zone of combustion intensifies the force of the fire and, by reason of the exothermic reactions which it brings about, adds to the calorific power of the fuel, which will diminish the consumption of the latter. M.V.C.

**Continuous measurement of gas compositions.** WILLIAM F. HAMILTON. *Trans. Amer. Inst. Chem. Engrs.*, **29**, 292–324 (1933).—As the use of gases for commercial synthesis or reaction becomes more common, the standard intermittent methods of gas analysis are being replaced by continuous, automatic, and more rapid methods. Thermal conductivity cells are particularly applicable for this purpose. A.P.

**Diffusion of gases.** W. ROTH. *Arch. Eisenhüttenwesen*, **8**, 401–403 (1935).—Simple equations are presented for computing the diffusion of gases. The influences of the molecular weight of various gases present and of temperature, pressure, and range of density are discussed. Experiments demonstrated the application of the equations and the rate of diffusion taking place under plant conditions. W.M.C.

**Dressler tunnel kiln's genesis.** CONRAD DRESSLER. *Bull. Amer. Ceram. Soc.*, **14** [6] 216–17 (1935).

**Effects of combustion methods on temperature uniformity of kilns and furnaces.** F. O. SUFFRON. *Bull. Amer. Ceram. Soc.*, **14** [6] 197–202 (1935).

**Efficiency of kilns.** F. A. WHITAKER. *Bull. Amer. Ceram. Soc.*, **14** [6] 194–97 (1935).

**Efficiency of pottery kilns.** B. HELAN. *Zprávy Československ. keram. spolecnosti*, **10**, 21 (1933).—A systematic study carried on by the Czechoslovak Ceramic Society shows that the firing temperature of stoneware pottery is about 1250°C, and the consumption of fuel is 133 to 197 kg. of coal with 4500 Kcal. for 1 m.³ of the kiln contents. The losses are about 45%, and the amount of the accumulated calories is 67,000 to 260,000 for 1 m.² of the inner kiln surface. R.B.

**Evaluation of ash-correction formulas based on petrographic analyses.** C. G. BALL AND G. H. CADY. *Econ. Geol.*, **30** [1] 72–88 (1935).—The authors undertook the systematic separation of mineral constituents from a column of representative Illinois coal. The predominating minerals were calcite, pyrite, and kaolinite. Assuming that the quantity of predominating minerals determines the quantity of ash, they consider the validity of the Parr unit coal formula as a means of getting mineral matter from the items of the proximate analysis. The formula contains errors but these are normally compensating, making the formula valid for coals of average ash composition. Serious errors may result if the coal contains much kaolinite, calcite, or both, and particularly if the ratio of sulfur to ash is very low. Mineral values will be too low. Mineral values for high-sulfur coals are likely to be too high. A general correction formula for calcite is not desirable, except in low-sulfur coals, where the sulfur to ash ratio is low. J.L.G.

**Firing a Hoffman kiln with coal.** S. I. SELIKIN. *Stroitel. Material.*, No. 9, pp. 55–58 (1934).—S. discusses experiences leading to considerable economy in fuel. P.B. & E.S.

**Fundamentals, rules, and examples of computing furnaces. II.** H. SCHWIEDESSEN. *Arch. Eisenhüttenwesen*, **8**, 329–36 (1935).—Uses of the formulas given in Part I are shown. A compilation of formulas is presented for computing the amounts of dry and moist flue gases and the amounts of primary and secondary air for hearths. For Part I see *Ceram. Abs.*, **14** [5] 123 (1935). W.M.C.

**Heat theory, radiation, load losses, absorption, etc.** C. F. MAYER. *Ind. Heating*, **2** [5] 261–63 (1935).—Results of tests on kind and distribution of losses in furnaces with walls of different materials and thickness are discussed, and data of heat losses and energy consumption are given. The theory is discussed briefly. M.H.

**Heat treating by forced convection.** J. R. MORRISON. *Ind. Heating*, **2** [5] 245–46 (1935).—The most efficient way to raise the temperature of material is by forced convection rather than by conduction or radiation; up to about 1300°F, the recirculating heater has recently been applied successfully. The air is brought into intimate contact by fans with the hot combustion gases, flame, or electric heaters and then properly directed to the material to be heated. Examples of drying ovens, heating furnaces, etc., are described. M.H.

**Kiln installations of the refractory plant of the Kuznetzk iron and steel works.** A. P. KOZHIN. *Ogneuporui*, **3**, 83–97 (1935). P.B. & E.S.

**Mendheim kiln corner chambers.** D. A. KISSIN. *Ogneuporui*, **3**, 120–26 (1935).—Corner chambers of Mendheim kilns have characteristic peculiarities as to their work, leading to a longer firing period and to an increase in the amount of unsatisfactorily fired material. A reconstruction of a kiln, undertaken to improve its work, is described. P.B. & E.S.

**Method of correlating forced convection heat-transfer data and a comparison with fluid friction.** ALLAN P. COBURN. *Trans. Amer. Inst. Chem. Engrs.*, **29**, 174–211 (1933).—A general method for the correlation of forced convection heat-transfer data is proposed which consists in plotting $(h/cG)(c\mu/k)$ against $(dG/\mu)$, where $h$ is the film coefficient of heat transfer between fluid and solid; $c$, specific heat of the fluid; $G$, weight of fluid flowing per unit time and unit cross-sectional area; $\mu$, viscosity of the fluid; and $d$, the diameter. A.P.

**Orsat gas analysis.** F. STRAEHUBER. *Arch. Tech. Mess.*, **3**, 36-377 (1934).—Practical instructions for taking samples and making analyses of fuel and combustion gases of furnaces and boilers are given in detail; the apparatus required for it is described. M.H.

**Physical characteristics of electric gas purification.** G. MIERDEL AND R. SEELIGER. *Arch. Elektrotech.*, **29** [3] 149–72 (1935).—A review is presented of the present knowledge of electric gas purification based on actual use of such equipment in plants over a period of several years. Numerous graphs and data are given. See also *Ceram. Abs.*, **13** [8] 219 (1934) W.M.C.

**Principles for calculating heat economy of furnaces.** W. HEILIGENSTAEDT. *Stahl & Eisen*, **55** [12] 334–37 (1935).—Methods for calculating heat economy are

discussed. Theoretical considerations often present simple solutions for many plant problems. More research data are required, however, to cover all influences which may play a part under actual conditions in a plant. W.M.C.

**Propane and butane as industrial gases.** H. BRÜCKNER. *Gas & Wasserfach*, **77** [25] 425–29 (1934).—The two gases are present in natural gas or are separated from oils; natural gas contains up to 6% butane and up to 25% propane. The upper heating values are 30,500 and 24,240 kg. cal./m.³, respectively, the lower values, 28,100 and 22,270, respectively. They are also obtained in the liquefaction of coal. Their manufacture, properties, and application as fuel and carburizing agent are described. The gases, pure or mixed with others, especially city gases, are particularly suitable in compressed form for isolated plants, residences, farms, etc. M.H.

**Protection of the surface of electrodes of electric furnaces from oxidation.** G. F. MORENKO. *Domez*, **7** [1] 61–62 (1935).—The oxidation of carbon electrodes used in melting steel and ferrous alloys begins at 400°C; that of graphite electrodes begins at 600°C. According to Kotny, the standard burning off of electrodes is expressed by the following figures:

| Electrodes | Diameter (mm.) | Standard burning off (kg./hr./m.²) |
|---|---|---|
| Graphitized | Up to 175 | 0.8 |
| Graphitized | 200 to 300 | 1.0 |
| Graphitized | Above 300 | 1.55 |
| Carbon | Up to 450 | 2.2 |

The standard expenditure of electrodes for 15-ton furnaces is 9 kg. per ton of steel. To protect the surface of electrodes, coatings made from soluble glass and refractory components (refractory clay, dust grog, or kaolin) have been used. At low and average temperatures (800 to 900°C), the adherence was firm but at the working temperatures the coatings melted and flowed off. Better results have been obtained with coke dust and sand. Experiments were made to cover the electrodes with thin layers (0.15 to 0.2 mm.) of Al, Cu, steel, and iron by methods of metallization. The best results have shown layers of iron and steel 0.2 mm. thick. These protect the electrodes from oxidation at temperatures from 1000 to 1100°C. S.I.P.

**Temperature-time relations resulting from the electrical heating of the face of a slab.** ALBERT B. NEWMAN. *Trans. Amer. Inst. Chem. Engrs.*, **30**, 598–614 (1934).—A theoretical analysis is given of the temperature-time relations for heat diffusion through slabs being heated or cooled, with boundary conditions involving the maintaining of a constant temperature either at the face or within the medium. The results are reduced to a form usable by designers. Tables and curves illustrate the application to cases of heating to a desired temperature at the center without heating the face above a permissible maximum. A.P.

**Waste-gas analysis for $CO_2$ or $O_2$.** H. GRUESS AND F. LIENEWEG. *Arch. Tech. Mess.*, **3**, 8-97 (1934).—It is often more convenient and useful to check combustion processes by determination of the $O_2$ content of the waste gases than by determination of CO, $CO_2$, or $H_2$. If $O_2$ is determined, the $CO_2$ content is easily found, as to each $O_2$ a definite $CO_2$ value belongs; for this relation a formula is given. Particular advantages of this method of combustion control in cement and lime kilns and for ceramic firing processes are discussed. It is also suitable for control when firing with a reducing flame, as the method is independent of other constituents present in the combustion gases. 8 references. M.H.

BOOK

**Electrical furnaces.** A. V. SSIBILEV. Chief Editorial Office of Non-Ferrous Metallurgy, Moscow, Leningrad, and Sverdlovsk, 1934. 738 pp. Price 11R. The book represents a fundamental manual on electric furnaces, which are being used to a greater extent in all branches of industry and household economy. The electrical furnace offers many advantages and conveniences and its work is precise and flexible. A description is given of the construction, work, and calculations of the resistance, arc, and induction furnaces. More than 500 illustrations, curves, and diagrams make it a useful contribution for engineers, research workers, and students interested in the construction and use of such apparatus. Characteristics are given of the properties of different materials used for the construction of electric furnaces, *i.e.*, metal and nonmetal conductors, electrodes, refractories (fire clay, silica, bauxite, Alundum, beryllium oxide, silicon carbide, chromite, graphite), and plastic and heat-insulating materials (kieselguhr, Sil-O-Cel, etc.). The book will be of practical value, especially to those interested in electromelting of corundum, alumina cements, silicon carbide, metals and nonmetals, and different heating processes. S.I.PERKAL

PATENTS

**Conveyer for kilns.** L. L. LADD. U. S. 2,003,450, June 4, 1935 (Jan. 15, 1934).

**Glaze for nonmetallic resistors.** ERNST HEDIGER (Globar Corp.). U. S. 2,003,592, June 4, 1935 (Jan. 3, 1933). A silicon carbide heating element has a body portion substantially devoid of materials other than silicon carbide, the major portion of the silicon carbide being relatively coarse, and a surface coating of more finely divided silicon carbide which is bonded with a vitrifiable bonding agent.

**Kiln.** L. L. LADD. U. S. 2,003,451, June 4, 1935 (Jan. 26, 1934).

**Method of burning fuel gas.** H. C. WELLER (Surface Combustion Corp.). U. S. 2,003,226, May 28, 1935 (July 20, 1933). In the operation of a gas-fired furnace the described method of maintaining combustion consists in projecting into the combustion chamber a horizontally stratified stream of the two components, air and gas, of a combustion mixture, the stream including an intermediate stratum of mingled air and gas, overlaid by a stratum of greater air content, and underlaid by a stratum of greater gas content, the effect being that the flame produced is of decreasing luminosity from the lower portion of the combustion chamber upward.

## Geology

**Chrome.** GORDON H. CHAMBERS. *Foote-Prints*, **8** [1] 1–9 (1935).—Occurrence, preparation, and uses of chromium ore are given. A.P.

**Clay and kaolin.** H. JUNG. *Münch. med. Wochschr.*, **81**, 1888–90 (1934); *Ind. Hygiene Abs.*, **17** [2] 36–37 (1935).—A general discussion of clays, their occurrence, composition, and properties is given. Clay may be decomposed by concentrated sulfuric acid and partially decomposed by hydrochloric acid, the silica remaining for the most part as a gel. Clays are a mixture of allophane (an amorphous substance of indefinite composition) and kaolin (a crystalline substance, $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$). A table shows that over 90% of a normal clay consists of grains less than 5.5$\mu$ in diameter, and approximately half of this consists of grains less than 1$\mu$. A microscopic study indicates that impurities such as quartz, feldspar, and mica also occur. Since the feldspar and quartz make up the coarser grains, they are easily removed by washing. Since the finest grains can not be studied microscopically, X-ray photographs are used, which show that nacrite and dickite as well as kaolin occur in the finest material. Mica is also present, but feldspar and quartz are lacking. A method of determining the amount of kaolin in the clay involves the amount of water given off at a temperature of 420°. Montmorillonite contains calcium and magnesium. E.J.V.

**Feldspar.** G. H. MCINTYRE. *Enamelist*, **12** [8] 25–27 (1935).—Feldspars make up about 60% of the igneous rocks. The type known as "pegmatite" is used for commercial purposes due to lower treatment charges. The most important feldspars are orthoclase, microcline, albite, and anorthite. Open quarry methods are used for mining the great bulk of feldspar. The glass industry requires coarsely ground material, 20- to 40-mesh, while the other ceramic industries commonly use 200-mesh material. Methods of grinding and controlling the composition of the delivered product are discussed. Illustrated. E.J.V.

**Fluorides, their use in the ceramic industries.** A. GRANGER. *Céram., Verrerie, Émail.*, **2** [12] 509–13 (1934).—Fluorides used in ceramics are cryolite ($AlF_3 \cdot 3NaF$) and fluorspar ($CaF_2$). They are used as opacifiers in the enameling and glass industries. Hydrofluoric acid is used in the etching of glass. The minerals have been proposed for lowering the fusion point of porcelains. Representative batches using fluorides are given. M.H.B.

**Industrial recovery of leucite.** B. GRANIGG AND H. BENESCH. *Metall & Erz*, **31** [9] 193–97 (1934).—A microscopic study was made of an Italian leucite deposit. From the structural studies it was possible to select the most economically advantageous deposits to be worked. The microscopic studies also indicated the fineness of grinding necessary for the most profitable extraction of the leucite by mineral acids. Chemical analyses are given of the fractions of various particle-size ranges. L.T.B.

**Lithium ores and lithium salts.** G. H. CHAMBERS AND E. G. ENCK. *Foote-Prints*, **7** [1] 1–11 (1934).—Sources, manufactured salts, and uses of lithium are presented. A.P.

**Manganese.** G. H. CHAMBERS. *Foote-Prints*, **7** [2] 11–21 (1934).—Occurrence, preparation, and uses of manganese are given. A.P.

**Physicochemical properties of Japanese acid clay. VI. X-ray studies on Japanese acid clay.** KEN-ICHI YAMAMOTO. *Jour. Soc. Chem. Ind.* [Japan], **34** [7] 244–47*B* (1931); **35** [10] 482–86*B* (1932). **VII. Solubility of Japanese acid clays to alkaline solutions and the essential constituents of acid clay.** *Ibid.*, **36** [2] 38–42*B*; [8] 460–66*B* (1933). **VIII. Polarizing microscopic studies of Japanese acid clay. IX. Refractive index of the clay, and considerations on results of these studies.** *Ibid.*, **37** [2] 90–96*B* (1934). **X. Experimental formula of crystalline aluminum silicate in Japanese acid clay.** *Ibid.*, **37** [5] 272–75*B* (1934).—Results are shown in tables. For Parts II–III, see *Ceram. Abs.*, **7** [8] 578 (1928). M.V.C.

**Rarer elements.** P. E. BROWNING. *Foote-Prints*, **7** [2] 1–10 (1934).—B. points out important uses which have been evolved for lesser known elements during the last thirty-five years. A.P.

**Salts of rare earths in the ceramic industries.** ALBERT DEBECQ. *Verre & Silicates Ind.*, **6** [6] 100–101 (1935).—A general outline of the uses of rare earths in (1) glass-making for coloring, decoloring, and raising the index of refraction (titanium oxide), (2) the enamel industry as opacifiers and for increasing chemical resistance, and (3) ceramics; the great opacifying power of cerium oxide permits the coating of ordinary terra cotta with white enamel. M.V.C.

**Sugarloaf Butte alunite.** ROBERT E. S. HEINEMAN. *Eng. Mining Jour.*, **136** [3] 138–39 (1935).—The deposit of alunite in Yuma County, Ariz., consisting of five claims, occurs as branching irregular veins in the dacite rock which forms the base of the butte. These veins appear to constitute about 10% of the rock exposed by the workings but are not uniformly pure. A recent analysis on a large sample of high-grade vein material gives $Al_2O_3$ 36.5, $SO_3$ 38.1, $K_2O$ 4.85, $Na_2O$ 4.3, $SiO_2$ 1.2%. This carries more alumina and less silica than the Marysvale, Utah, deposit. More field work is needed to show the structure of the area and to determine the extent of the deposit. J.L.G.

**World resources of bauxite.** V. C. *Rev. mat. constr. trav. pub.*, No. 305, pp. 43–45 (1935).—White bauxite is rare, world resources being estimated at about one million tons. The removal of iron oxide from red bauxite (which is more common) so that it can be used, is being studied. The U. S. imports 30,000 tons of bauxite from Europe annually. M.V.C.

BOOK

**Soviet Mineralogy and Geochemistry from 1929 to 1934.** Pub. House Acad. Sci., U.S.S.R., Leningrad and Moscow, 1935. 104 pp. Price 2R 25k. An interesting and authoritative summary of the developments of Soviet crystallography and geochemistry is given S.I.PEREKAL

## Chemistry and Physics

**Analysis of silicates not attacked by acids.** M. HAUSSONNE. *Céram., Verrerie, Émail.*, **2** [8] 351–54; [9] 395–402 (1934).—H. gives a detailed scheme of analysis for clays or like materials, including the determination of $SiO_2$, $Al_2O_3$, $Fe_2O_3$, CaO, MgO, $K_2O$, and $Na_2O$. M.H.B.

**Artificial metasilicate of manganese.** N. L. DILAKTORSKI. *Trans. Petrograph. Inst. Acad. Sci.* [U.S.S.R.], **6**, 369–79 (1934).—Synthetic rhodonite ($MnSiO_3$) with 3.8% tephroite and $SiO_2$ was obtained. It had a light rose color, a melting point of 1310°C, specific gravity of 3.766, birefringence of 0.0097, and was of the triclinic system. S.I.P.

**Bora.** S. R. SCHOLES. *Bull. Amer. Ceram. Soc.*, **14** [6] 206 (1935).

**Changes of the magnetic properties of mixtures of Be-, Ca-, Cu-, Cd-, and Pb-oxides with chromium (III) oxide during their chemical combination.** HERBERT KITTEL. *Z. anorg. allgem. Chem.*, **222** [1] 1–11 (1935).—The changes in the magnetic susceptibility of the following compositions were measured after heating at various temperatures from room temperature to 1000°C: $BeO/Cr_2O_3$, $CaO/Cr_2O_3$, $CuO/Cr_2O_3$, $CdO/Cr_2O_3$, and $PbO/Cr_2O_3$. The results are tabulated in detail. The significance of the changes of magnetic properties at the various temperatures is discussed briefly. L.T.B.

**Electron diffraction as a method of research.** G. P. THOMSON. *Nature*, **135** [3413] 492–96 (1935).—The methods of producing electron diffraction patterns are explained, and the information to be secured from such patterns is considered. 22 references. J.L.G.

**Glassy phase in the manufacture and use of refractories.** GEORGE W. MOREY. *Bull. Amer. Ceram. Soc.*, **14** [6] 202–206 (1935).

**Lattice dimensions of zinc oxide.** G. I. FINCH AND H. WILMAN. *Jour. Chem. Soc.* [London], 751–54 (1934).—Previous determinations of the lattice constants of zinc oxide have been revised by electron-diffraction measurements. For the close-packed hexagonal lattice of zinc oxide, $c/a = 1.607 \pm 0.002$ has been obtained directly from zinc oxide transmission diffraction patterns. Individual values for the axes, $a$ and $c$, have been found by reference to a superimposed diffraction pattern due to gold. $a = 3.258 \pm 0.005$Å and $c = 5.239 \pm 0.005$Å. A.P.

**Law of phases and diagrams of equilibriums in the study of industrial silicates.** LEON FRANCQ. *Verre & Silicates Ind.*, **6** [3] 38–42; [4] 57–61 (1935).—The physicochemical study of industrial silicates is based on equilibrium diagrams established according to the law of phases. The subject is analyzed clearly and simply under the following headings: (1) definition of the law of phases, (2) study of heterogeneous equilibriums at high temperature, (3) systems of one constituent, (4) systems of two constituents, and (5) diagrams of binary equilibriums. M.V.C.

**Measurement and control of hydrogen-ion concentration in industrial plants.** GEORGE A. PERLEY. *Trans. Amer. Inst. Chem. Engrs.*, **29**, 257–92 (1933).—A description and limitations of the various methods for measuring $p_H$ are given. See also *Ceram. Abs.*, **13** [1] 25 (1934). A.P.

**Piezo-electrical determination of the hardness of materials.** E. FRANKE. *Messtechnik*, **10** [12] 221–23 (1934).—Instead of measuring the hardness of a material by the rebound of a steel ball falling on the specimen, the electric charge is measured which is produced in a quartz crystal placed underneath the specimen by the impact of the ball on the specimen and transmitted through it to the quartz. This method has, however, more or less relative value. The relation of values so obtained with values by other familiar measuring methods is discussed. M.H.

**Polymerization and adsorption capacities of silicates compared.** YA. M. SLOBODIN. *Zhur. Prikladnoĭ Khim.*, **8** [1] 35–43 (1935).—The capacity of silicates and other porous bodies to adsorb tarry and asphaltic substances from oil products is important. Comparison of the polymerization and adsorption capacities of the silicates, kaolin, trass, and silica gel, are given. The following conclusions are drawn: (1) The polymerization capacity of silicates is maximal at the temperature of activation, 300 to 325°C. Silicates activated under 200°C and above 600°C are incapable of producing polymerizations. (2) The polymerization capacity of silicates depends not only on the degree of de-watering but also on the interstructural changes taking place on heating. (3) Silica gel has no polymerization capacity. (4) Silicates having great polymerization capacity also have great adsorption capacity. (5) The adsorption capacity does not depend upon the temperature of activation within the limits from 600 to 650°C. S.I.P.

**Possibilities and limitations of large-size shadowgraphs obtained by X-rays.** R. BERTHOLD. *Arch. Eisenhüttenwesen*, **8**, 425–26 (1935).—Weldings and steel samples of various thicknesses were tested. Flaws in the samples could readily be detected when the distance between the X-ray tube and the sample was less than about 2 ft. Increasing the distance to 9 or 12 ft. concealed the details in the pictures considerably. The voltage of the tubes was from 200,000 to 250,000 volts. The use of intensifying screens is emphasized. W.M.C.

**Quantitative determination of silica in insoluble silicates. IV. Silica and silicates.** F. W. MEIER AND L. STUCKERT. *Z. anal. Chem.*, **101** [3–4] 81–84 (1935).—The perchloric acid method for quantitative determination of silica in soluble silicates is used in combination with the J. Lawrence Smith decomposition method for the determination of silica in insoluble silicates. The results compare favorably with those obtained with the usual method of decomposition with soda and subsequent evaporation with hydrochloric acid. In accuracy of results and rapidity with which it can be carried out, the modified perchloric acid method is superior for the quantitative determination of silica in insoluble silicates. For Part III see *Ceram. Abs.*, **11** [9] 504 (1932). E.J.V.

**Quantitative determination of zirconium with *o*-hydroxyquinoline.** G. BALANESCU. *Z. anal. Chem.*, **101** [3–4] 101–108 (1935).—Zirconium produces an insoluble precipitate with *o*-hydroxyquinoline, and this reaction

can be used for its gravimetric determination. To obtain the same composition of the zirconium-hydroxyquinoline complex $(C_9H_6ON)_4Zr$, the solution containing the zirconium is treated with nitric acid under certain conditions, so that the zirconium is converted to $Zr''''$. The determination can be made volumetrically as well as gravimetrically. In the volumetric determination the zirconium-hydroxyquinoline precipitate is dissolved in 50% sulfuric acid and the determination is made by the hydroxyquinoline according to R. Berg. In the gravimetric determination, the hydroxyquinoline complex is weighed directly after drying or it is ignited and the resulting zirconium dioxide is weighed. The volumetric method has certain advantages; it is more rapidly carried out and is not affected if the precipitate is in a solution with foreign ions present. E.J.V.

**Section $CaO{\cdot}SiO_2$–$MnO{\cdot}SiO_2$ in the ternary system $SiO_2$–CaO–MnO.** Ernst Voos. *Z. anorg. allgem. Chem.*, **222** [2] 201–24 (1935).—The studies in the system were made in induction and resistance furnaces under high vacuum. The furnaces are described in detail. A new type of regulator was devised for resistance furnaces by which temperatures were maintained to +0.17°. The quenching method was used for temperature determination. Pure $MnO{\cdot}SiO_2$ was synthesized. A continuous series of solid solutions exists between $\alpha CaO{\cdot}SiO_2$ and $MnO{\cdot}SiO_2$. Liquidus and solidus curves were located. The temperature of the $\alpha$–$\beta$ change of $CaO{\cdot}SiO_2$ is increased by the presence of $MnO{\cdot}SiO_2$. Indices of refraction of the crystals were measured. The effect of varying composition on the unit cell and specific gravity of the crystals in the system was determined from X-ray studies. A detailed review of previous investigations of the system is included. L.T.B.

**System calcium oxide–phosphorous pentoxide.** Gerhard Trömel. *Mitt. Kaiser-Wilhelm Inst. Eisenforschung Düsseldorf*, **14**, 25–34 (1932).—Phase equilibria have been determined between 25 and 70 wt.% CaO with the following results as read from the diagram given: $CaO{\cdot}P_2O_5$ m.p. 925°C; $2CaO{\cdot}P_2O_5$ m.p. 1300°C, transition $\beta \rightarrow \alpha$ at 1150°C; $3CaO{\cdot}P_2O_5$ m.p. 1730°, transition $\beta \rightarrow \alpha$ at 1400°C; $4CaO{\cdot}P_2O_5$ m.p. 1710°C. Eutectics are as follows: $CaO{\cdot}P_2O_5$–$2CaO{\cdot}P_2O_5$, 970°C at 32% CaO; $2CaO{\cdot}P_2O_5$–$3CaO{\cdot}P_2O_5$, 1285°C at 47% CaO; $3CaO{\cdot}P_2O_5$–$4CaO{\cdot}P_2O_5$, 1580°C at 57% CaO; $4CaO{\cdot}P_2O_5$–CaO, 1660°C at 63% CaO. Temperatures were determined chiefly by means of heating and cooling curves. Phases were identified by microscopic and X-ray examination of melts cooled to room temperature at a "normal" rate. The properties of the compounds found, as given by Hans Schneiderhöhn in an appendix, are as follows: *$CaO$–$P_2O_5$*. Occurs in fibrous aggregates with cleavage on a pinacoid face. Extinction parallel to the cleavage. Fiber axis 28° to cleavage and extinction. Biaxial, negative, probably rhombic, axial plane coincides with cleavage. Axial angle $2E = 100°$, refractive index ($n$) for Na light, $n_\alpha$ 1.588, $n_\gamma$ 1.595. Unetched in 2% citric acid and 5% HCl. Feebly etched after 10 min. in 1:1 HCl. *$2CaO$–$P_2O_5$*. Dimorphous, *$\alpha$-$2CaO{\cdot}P_2O_5$*, high-temperature form. Coarse-grained stem-like crystals. Imperfect cleavage in two mutually perpendicular directions. Biaxial, positive, $n_\alpha$ 1.585, $n_\gamma$ 1.604, always strongly twinned. Axial plane in direction of principal twinning lamellae, which have symmetrical extinction. Unaffected by 2% citric acid. Appreciably etched by 5% HCl after 10 min. *$\beta$-$2CaO{\cdot}P_2O_5$*. Medium-grained aggregate of isometric crystals, showing quadrilateral outline. Good cleavage parallel to 100 plane and somewhat less good parallel to 110. Uniaxial, positive, tetragonal, $n_\alpha$ 1.624, $n_\gamma$ 1.628. Not attacked by 2% citric acid. Somewhat more etched by 5% HCl than the $\alpha$ form. *$3CaO{\cdot}P_2O_5$*. Dimorphous, *$\alpha$-$3CaO{\cdot}P_2O_5$*, high-temperature form. Rather coarse-grained. No perceptible cleavage, $n_\alpha$ 1.588, $n_\gamma$ 1.591. Biaxial, positive, $2E$ about 75°. Many grains show narrow twinning lamellae, sometimes in two perpendicular directions. Extinction inclined to joint face. Insoluble in citric acid. Visibly attacked by 5% HCl in 2 min. *$\beta$-$3CaO{\cdot}P_2O_5$*, low-temperature form. Extremely fine-grained, strongly indented. $n_\alpha$ 1.620, $n_\gamma$ 1.622. Etched by 2% citric acid in 2 min. *$4CaO{\cdot}P_2O_5$*. Occurs in thin plates. Biaxial negative, probably triclinic. Cleavage incomplete along two approximately mutually perpendicular pinacoidal faces. $n_\alpha$ 1.643, $n_\gamma$ 1.647. Always has fine twinning lamellae resembling plagioclase. Extinction at 18° to the joint face of the lamellae. Axial plane lies in this face. Axial angle 80°. Etched in 2 min. by 2% citric acid. No indication of oxyapatite ($10CaO{\cdot}3P_2O_5$) was found. The formation of hydroxylapatite ($Ca_{10}P_6O_{24}$)($OH_2$) was observed at 1050 to 1100°C. Decomposition was complete at 1400°C. J.B.A.

**Theory of mineral flotation. Actual state of knowledge of the reactive collectors.** M. Rey. *Rev. universelle mines*, **10** [16] 433–39, 466–71 (1934).—R. discusses the mechanism of flotation. In recent years it has been found that a series of organic compounds which are soluble in water can be used to advantage in flotation. These compounds are referred to as "collectors" and are largely used in the flotation of sulfides. These collectors form a film on the surface of the mineral in consequence of characteristic chemical groups which they contain. The film formation may result from a chemical reaction or it may be due to an adsorption phenomenon. Arguments in substantiation of both theories are advanced. The effect of ions released by the minerals into the solution on the film formation is discussed. L.T.B.

**Thermal behavior of the kaolin minerals.** Herbert Insley and Raymond H. Ewell. *Jour. Research Nat. Bur. Stand.*, **14** [5] 615–27 (1935); R.P. 792. Price 5¢. When the kaolin minerals, kaolinite and dickite, are heated at rates from 5 to 30°C per min. there are two large and significant heat effects. The lower one, a broad but intense endothermic effect, is associated with the loss of water and the dissociation into an exceedingly intimate mixture of amorphous alumina and amorphous silica. The upper one, a sharp and intense exothermic effect, is associated with the formation of $\gamma$-$Al_2O_3$ from amorphous $Al_2O_3$. The evidence supports the conclusion that the formation of $\gamma$-$Al_2O_3$ at much higher temperatures in the kaolin minerals than in amorphous alumina is due to the restraining action of the rigid amorphous silica network on the crystallization of the alumina. In synthetic alumina-silica gels an exothermic effect at the same temperature and of the same character is observed with crystal-

lization of mullite (or of mullite and $\gamma$-$Al_2O_3$) instead of $\gamma$-$Al_2O_3$. Apparently the nature of the resultant crystalline phase depends upon the internal structure of the material. R.A.H.

**Thermal expansion of monocrystalline and polycrystalline antimony.** PETER HIDNERT. *Jour. Research Nat. Bur. Stand.*, **14** [5] 523–44 (1935); R.P. 784. Price 5¢. R.A.H.

**X-ray examination of fine structure.** W. E. SCHMID. *Arch. Tech. Mess.*, **3** [4] 48–49*T*; [5] 62*T*; [6] 77*T*; **4** [7] 94*T* (1934).—The determination of the lattice structure of materials and, by it, of their physical and chemical behavior by employing X-ray spectroscopy is explained, and crystal systems and apparatus are described. The various methods for detecting interior stresses in the material and other crystalline disturbances are discussed. M.H.

BOOK

**Annual Survey of American Chemistry. Vol. IX (1934).** Edited by CLARENCE J. WEST. Published for the National Research Council by the Reinhold Publishing Corp., New York, 1935. 370 pp. Price $4.50. Twenty-nine authors contribute twenty-five chapters on the survey of American chemistry for 1934. The various fields of chemistry, except biochemistry, are covered. The chapters more closely related to ceramics are (1) theories of solution, (4) thermodynamics and thermochemistry, (5) colloids, (9) X-ray examination of materials, and (25) chemical engineering. A complete bibliography is included at the end of each chapter. H.E.S.

PATENT

**Treatment of lime aluminates.** J. C. SEAILLES. Brit. 428,584, May 29, 1935 (Nov. 29, 1933).

## General

**Amortization, depreciation, obsolescence, and replacement.** WYMAN P. FISKE. *Trans. Amer. Inst. Chem. Engrs.*, **30**, 1–36 (1934).—Accounting concepts applied to management and engineering department decisions on the economics of the purchase of new equipment are discussed. A.P.

**Analysis of dust samples employing X-ray diffraction.** W. F. BALE AND W. W. FRAY. *Jour. Ind. Hygiene*, **17** [1] 30–32 (1935).—A method for studying the problem of pneumoconiosis and other dust hazards employing X-ray diffraction permits a qualitative analysis of dust without resorting either to chemical, petrographical, or biological methods. E.J.V.

**Annual report of the chief inspector of factories and workshops (1933).** MEREWETHER. Abstracted in *Foundry Trade Jour.*, **51** [938] 91–92 (1934).—The report deals with silicosis and sandblasting. H.E.S.

**Building material.** V. CHARRIN. *Rev. mat. constr. trav. pub.*, No. 305, pp. 45–46 (1935).—When properly agglomerated, pumice shows the following properties and advantages as a building material: (1) Lightness; 1 cu. m. of "graviponce" (building pumice) weighs 600 to 650 kg. (2) Sound insulation is 8 times greater than that of clay brick. (3) Thermal insulation; the coefficient of conductivity is 0.20, contrasted with 0.70 of ordinary brick. (4) Resistance; the breaking load is 100 kg./sq. cm. It is stable to acids and does not change at high temperatures, its low absorption of water makes it resistant to moisture and freezing. It can be sawed and nailed like wood. M.V.C.

**Colorimetric determination of $p_H$ at elevated temperatures.** WALTER NEUMANN. *Z. anal. Chem.*, **94** [3–4] 89–96 (1933).—Samples of redistilled water were treated with various indicator solutions, heated to 98°, and cooled to 20°; the process was repeated several times. The $p_H$ was increased from 6.0 to 7.0 on the first heating as a result of the elimination of $CO_2$ that had been absorbed from the air. On cooling, the $p_H$ increased to 8.0. On further heating to 98°, the $p_H$ returned to 7.0 and, on cooling to 20°, it increased again to 8.0. *Ibid.*, **96** [5–6] 175–83 (1934).—Sodium chloride solutions of different concentrations were treated with suitable indicators, repeatedly heated to boiling, and cooled out of contact with air containing $CO_2$. There tended to be a decrease in the $p_H$ values as a result and this decrease was more marked as the concentration of the salt was low. With pure water a change of 0.96 unit was noted, but with 25% sodium chloride there was a loss of only 0.24 unit. The results were similar with potassium chloride solutions. *Ibid.* **101** [3–4] 89–101 (1935).—Similar studies were made using sodium and potassium sulfate solutions. In the experiments with sodium sulfate solutions, following the boiling out of the air and cooling to 20°, on reheating the dilute solutions a slight change in color was noticeable in the case of the low concentration, but with higher concentrations it was an opposite color change than that observed with sodium or potassium chloride solutions. With potassium sulfate the results were similar to those obtained with sodium or potassium chloride. N. determined that the change in color of the boiled solutions of neutral salts that had been treated with indicators was due to the change in ionic products of the water and also the change in magnitude of the salt breaking up, both of which are dependent on the temperature. From the results of the investigation, it was concluded that the decomposition of the salt decreases with rising temperatures and at about 100° it is zero or only a small fraction of the decomposition at 20°, a fact which is of practical importance in the colorimetric determination of the $p_H$ value of different salt solutions. Solutions of salts of strong acids with weak bases, such as magnesium sulfate, magnesium chloride, and calcium chloride, were studied in a similar manner and the results are discussed. E.J.V.

**Control of dust in sandblast apparatus.** E. A. VIGDORTSCHIK, N. F. STOSHKOWA, AND M. A. GOLOSCHTSCHOKINA. *Gigiena truda i tekhnika bezopasnosti*, No. 5, pp. 40–46 (1934); *Ind. Hygiene Abs.*, **17** [2] 34–35 (1935).—The dust content of the room air was investigated in the operation of the principal types of sandblast apparatus as to (1) equipment (type of apparatus, ventilation, etc.), (2) air pressure in the nozzle, and (3) type and grain size of the abrasive. The dust was determined at the same

time gravimetrically and with the Owens' apparatus. The effect of ventilation and the dust helmet were also tested. The hygienic improvement of the working conditions was summarized in the following manner: (1) Apparatus with stationary nozzles permits the best dust removal; apparatus with movable nozzles and without individual protection is not permitted. (2) The dust helmet with an air inlet which introduces not less than 170 liters/min. is to be available. The air for this line is not to have an unpleasant odor. A spherical air distributor can be applied. (3) There must be further investigation as to substitution of quartz sand in the sandblast apparatus with a metallic abrasive. E.J.V.

**Developments in methods of sampling dust.** H. L. GREEN. Presented at Inst. of Mining & Metallurgy, London, Nov. 15, 1934; *Ind. Hygiene Abs.*, **17** [2] 34 (1935).—From a critical study of dust-sampling instruments in common use, konimeter, jet dust counter, and impinger, G. concludes that none gives accurate data concerning either the number or size of industrial dusts. Compared with an "absolute" instrument such as the direct-counting ultramicroscope or G.'s settlement chamber, their efficiencies were 50% or less. As a universal instrument, sampling with perfect efficiency over a size range from 0.2 to 20$\mu$, G. proposes a thermal precipitator which deposits the dust sample on two cover glasses in a condition suitable for immediate microscopic enumeration and measurement. The efficiency is reported to be 100% compared with the ultramicroscope. The sampling rate is 7 cc./min.; this is obtained by water displacement from a reservoir to which the instrument is connected. See also *Ceram. Abs.*, **13** [4] 104 (1934). E.J.V.

**Dust-filtering efficiency of the human nose and its significance in the causation of silicosis.** GUNTHER LEHMANN. *Jour. Ind. Hygiene*, **17** [2] 37–40 (1935).—A method for determining the dust-retaining power of the human nose is described. The filtering efficiency of the nose among a varied group of men lay between 10 and 70%. The systematic study of 426 miners, some of whom were silicotic, showed that those with poor nasal filtration had far greater susceptibility to silicosis than those with good nasal filters. It is suggested, therefore, that the dust-retaining capacity of the nose be used as an index of the individual's qualification for working in a silicosis-producing atmosphere. E.J.V.

**Efficient working of hand-fired boilers.** F. J. MATTHEWS. *Brit. Clayworker*, **44** [517] 42–44 (1935).—Faults and effects are discussed in detail. R.A.H.

**Half-way house.** DAVID E. PIERCE. *Trans. Amer. Inst. Chem. Engrs.*, **29**, 100–13 (1933).—Between the test tube and the full-scale operating plant for a new process is the half-way house, the semi-works. P. believes that too little has been recorded in technical literature on the problems of organization, equipment, operating methods, economics, etc., here encountered, and presents some pointers. A.P.

**Measurement of dust quantities.** H. W. GONELL. *Arch. Tech. Mess.*, **3**, 43–44*T* (1934).—Methods for determining the quantity of dust present in the open atmosphere or in the air of shop and factory buildings are explained and the apparatus is described. The dust is determined either by weighing, by counting the dust particles in a unit space or area, or, for dark dusts such as soot, by determining the coloring effect. 31 references. M.H.

**Research.** ARTHUR POUND. *Atlantic Monthly*, **155** [4] 507–15 (1935).—General Electric Co.'s philosophy and organization of research are discussed. The future of research belongs not to the lone worker but to the informed and cohesive group of specialists. A high mortality exists among companies that have neglected the scientific approach to betterments. Research is the price of continued existence for any large industry depending upon marketing complicated goods and services. A.P.

**Research organization in the chemical industries.** H. G. GRIMM. *Stahl & Eisen*, **55** [13] 349–53 (1935).—The importance of research work applicable to manufacturing processes is emphasized. Details are presented regarding the large research laboratories of the German I.G. trust and of the organization of the work carried on there. W.M.C.

**Silicosis among potters.** A. LANGELEZ. *Bruxelles-Med.*, pp. 272–82 (Jan. 6); pp. 303–14 (Jan. 13, 1935); *Ind. Hygiene Abs.*, **17** [3] 58–59 (1935).—The pottery industry in Belgium is described with a detailed account of the dust generated. Free silica and sericite were found in the samples; the amounts of dust and the size of the particles present a definite dust hazard. A medical investigation was conducted at 19 factories, during which 915 workers were clinically examined, in some cases with X-rays. No clear signs of any prevalent silicosis were detected. It does not appear that "potter's rot" is expected to occur in these factories as in the English potteries. Powdered flint, the principal cause of trouble for potters, is replaced by coarse sand to separate the ware in saggers; possibly the absence of flint accounts for the absence of prevalent silicosis. E.J.V.

### BOOKS AND BULLETINS

**Calculations of glazes and masses for fine ceramics.** A. I. YOSSEVICH AND N. I. OKUN. Edited by A. I. Kramarenko. Ukrain. State Pub. House of Light Ind., Kiev, 1934. 64 pp. Price 1R 50k. After a short description of raw materials used in the fine ceramics, eight examples of calculations of materials and masses and four examples of calculations of glazes are given. E. I. Orlov's graphical method of calculation of materials, masses, and glazes is outlined in detail. The examples are taken from actual plant practice. S. I. PERKAL

**Review of literature on effect of breathing dusts with special reference to silicosis.** D. HARRINGTON AND SARA J. DAVENPORT. *Bur. Mines Information Circ.*, No. 6835, 68 pp. Free. This is the first of a series of circulars in which literature on dust diseases is collated, with special reference to mining and allied industries. R.A.H.

**Standardized roofing materials.** N. N. GRIGORIEV. State Pub. House "Standardization and Rationalization," Moscow, 1934. 48 pp. Price 1R 50k. The book embraces 17 official All-Union standards dealing with roofing iron, zinc-plated iron, corrugated iron, shale tile, flat roofing tile from artificial slate, clay roofing tile, cement-sand tile, wood cement, etc. S. I. PERKAL

**Standard samples issued or in preparation by the National Bureau of Standards.** ANON. Supp. to *Nat.*

*Bur. Stand. Circ.*, C398, Feb., 1935. 11 pp. Free. Averaged analyses of all samples sold by the Bureau are given. R.A.H.

PATENTS

**Ceramic articles and process of making.** NAAMLOOZE VENNOOTSCHAP MAATSCHAPPIJ TOT BEHEER EN EXPLOITATIE VAN OCTROOIEN. Brit. 428,329, May 22, 1935 (April 28, 1933).

**Colored granule.** W. H. ALTON (R. T. Vanderbilt Co., Inc.). U. S. 2,003,849, June 4, 1935 (Sept. 14, 1932).

**Colored granule and method of making.** W. H. ALTON (R. T. Vanderbilt Co., Inc.). U. S. 2,003,850, June 4, 1935 (Dec. 2, 1933).

**Method of artificially coloring roofing granules.** S. G. WRIGHT. U. S. 2,004,682, June 11, 1935 (Nov. 20, 1933).

**Vitreous compositions.** SOC. ANON. DES MANUFACTURES DES GLACES ET PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY, ET CIREY (Gaston Delpech and Roger Lambert, inventors). Fr. 767,372, July 17, 1934; *Chem. Abs.*, **29**, 311 (1935).—Magnesian micas, such as phlogopite and biotite, which are practically unattacked by vitreous fluxes, are heated with vitreous fluxes until the flux is softened and the mass is compressed in metal molds heated to about 400°.

## WANTED: ABSTRACTERS FOR THESE JOURNALS

The following journals contain material of interest to readers of *Ceramic Abstracts*. An abstracter for any of these journals should (1) have the journal available in his personal library or in some public, laboratory, or school library to which he has access, (2) be prepared to submit the abstracts regularly each month, and (3) (if the publication is printed in a foreign language) have a reading knowledge of the language in which the publication is printed. Address all requests for assignments to the office of *Ceramic Abstracts*, 2525 North High St., Columbus, Ohio. Journals will be assigned to those first requesting them.

Allgemeine Elektricitäts-Gesellschaft Mitteilungen
Allgemeine Glas- und Keram-Industrie
American Gas Association Report
American Mineralogist
Anales sociedad española de física y química
Annalen der Chemie
Annales de chimie analytique et de chimie appliquée
Annali di chimica applicata
Arch. Erzbergbau Erzaufbereit Metallhüttenwesen
Archiv für Gewerbepathologie und Gewerbehygiene
Archief voor de Suikerindustrie
Archiv für Wärmewirtschaft
Arts et Metiers
Atti della reale accademia nazionale dei Lincei
Bulletin of the Geological Society of America
Bulletin international de l'académie polonaise des sciences et des lettres, mathématiques et naturelles
Bulletin of the Missouri School of Mines and Metallurgy
Bulletin of the Montana Society of Engineers
Bulletin de la Société Française de Minéralogie
Bulletin of the U. S. Bureau of Labor Statistics
Calore
Canada Department of Mines Reports
Canadian Machinery
Chemical Age
Chemical Bulletin

*LIST OF JOURNALS CONTINUED ON OUTSIDE BACK COVER*

## WANTED: ABSTRACTERS FOR THESE JOURNALS

*(List continued from page 204)*

Chemical Markets
Chemical News
Chemie der Erde
Collection of Czechoslovak Chemical Communications
Colliery Engineering
Crushing, Grinding, Mining, Quarrying Journal

Decorator

Edison Electrical Institute Committee Report
Electrical World
Electrician
Elektrizitätswirtschaft
Emaillerie
Emailletechnische Monats-Blätter

Fachausschussberichte Deutschen Glastechnischen Gesellschaft
Földtani Közlony

Génie Civil
Gerlands Beitr. Zeitschrift Geophys.
Glaces et Verres
Glass Packer

Helvetica Chimica Acta

Indian & Eastern Engineer
Industria [Milan]
Industria chimica
Industrie chimique Belge
Industrie chimique [France]
Industria del Vetro e della Ceramica
Instrument World
International Bulletin of Information on Refrigeration
Iron Age
Iron & Steel Industry

Journal of Agricultural Science
Journal of the British Society of Master Glass Painters
Journal of Chemical Education
Journal of the Chemical, Metallurgical, and Mining Society of South Africa
Journal of Geology
Journal of Hygiene
Journal de pharmacie et de chimie
Journal of Physical Chemistry
Journal of Sedimentary Petrology

Keramische Rundschau
Kolloid-Zeitschrift

Lerindustrien

Management
Mechanical Handling
Mekhanicheskoi Obrabotki Poleznuikh Isokopaemuikh Mekhanobr
Metal Industry [N. Y.]
Metallbörse
Mineral Industry
Mineralogical Magazine
Mineralogische und Petrographische Mitteilungen
Mines, Carriers, Grandes Enterprises
Mining Congress Journal
Mining Journal (Phoenix)
Montanistische Rundschau

Nation's Business
Neues Jahrbuch für Mineralogie, Geologie, und Paläontologie
Notes & Queries

Official Yearbook of South Africa

Paint Manufacture
Paper Trade Journal
Physica
Pottery and Glass Record (England)
Power Engineer
Power & Fuel Bulletin
Proceedings of the Institute of Mechanical Engineers (London)
Przemysl Chemiczny

Reports of the Imperial Ceramic Experiment Institute
Reports of the National Physical Laboratory (London)
Research Laboratory Record
Revue générale des Sciences Pures et Appliquées
Revue industrielle
Revue d'Optique

Science
Science Abstracts
Science et industrie
Sheet Metal Industry (London)
Sitzungberichte Akademie der Wissenschaften in Wien
Soap
Steam Engineer
Studio (London)
Suiyokai-shi
Superphosphat

Technische Blätter
Teknisk Tidskrift
Tidsskrift for Kjemi og Bergvesen
Times Engineering Supplement
Times Literary Supplement
Toronto University Bulletin
Transactions of the Institute of Chemical Engineers [London]
Transactions of Institute of Gas Engineers
Transactions of the Royal Society of Canada

Umschau
U. S. Public Health Engineering Abstracts
University of Illinois Bulletin

Wärme
Waseda Applied Chemical Society Bulletin
West Virginia Engineering Experiment Station Bulletin

Zeitschrift der Deutschen Geologischen Gesellschaft
Zeitschrift Hochfrequenztechnische
Zeitschrift für Kristallographie
Zeitschrift für Pflanzenernährung Düngung und Bodenkunde
Zement
Zentralblatt Gewerbehygiene Unfallverhütung
Zentralblatt für Mineralogie, Geologie, und Paläontologie
Zhur. Tekh. Fiz.
Ziegelwelt